PRICE $2.00

HEATH COMPANY • BENTON HARBOR, MICHIGAN

HEATHKIT®
ASSEMBLY MANUAL

HEATHKIT

UTILITY SOLID-STATE VOLTMETER
MODEL IM-17

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TYPICAL COMPONENT TYPES

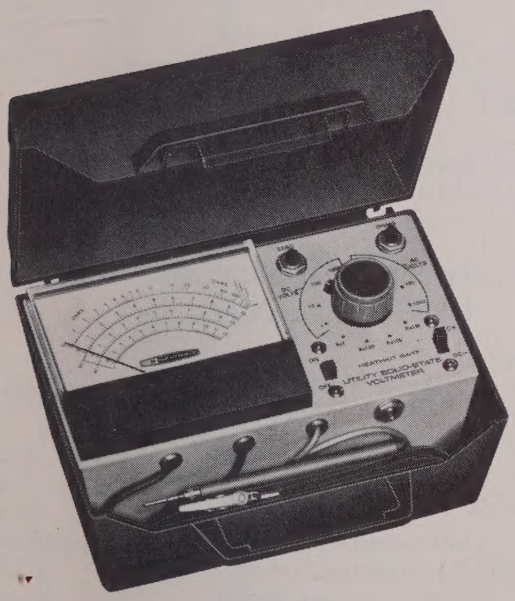
This chart is a guide to commonly used types of electronic components. The symbols and related illustrations should prove helpful in identifying most parts and reading the schematic diagrams.

Assembly
and
Operation
of the

HEATHKIT®

UTILITY SOLID-STATE VOLTMETER

Model IM-17



HEATH COMPANY
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INTRODUCTION

The Heathkit Model IM-17 Utility Solid-State Voltmeter is a compact, battery-powered volt-ohmmeter. It is accurate and easy to operate. The polypropylene case (with probe storage compartment) makes the meter especially suitable for service calls, as a portable instrument for use in the field, and for general utility use. Its simplicity makes it an ideal construction project for the novice in electronics.

The high input resistance of the Voltmeter on DC voltage ranges places very little loading on a circuit being tested. The 12-position selector switch provides four separate ranges each for DC voltage, AC voltage, and resistance measurements. A DC polarity switch allows upscale readings for either positive or negative voltages without the need of reversing test leads. The large 4-1/2 inch meter has four easy-to-read scales. An accessory jack permits you to use the Heathkit high voltage and RF accessory probes.

All these features combine to provide a versatile, accurate, and attractive test instrument that is designed for long and dependable service at minimum cost.

Refer to the "Kit Builders Guide" for complete information on unpacking, parts identification, tools, wiring, soldering, and step-by-step assembly procedures.

PARTS LIST

The numbers in parentheses are keyed to the numbers on the Parts Pictorial (fold-out from Page 3).

PART No.	PARTS Per Kit	DESCRIPTION
RESISTORS		
1/2 Watt		
(1) 1-41	1	10 Ω (brown-black-black)
1-20	2	10 kΩ (brown-black-orange)
1-22	2	22 kΩ (red-red-orange)
1-24	1	33 kΩ (orange-orange-orange)
1-35	1	1 megohm (brown-black-green)
1-38	2	3.3 megohm (orange-orange-green)
2 Watt		
(2) 3-4-2	1	9.1 Ω 5% (white-brown-gold-gold)
Precision		

NOTE: These may vary somewhat in appearance from the illustration.

(3) 2-236	1	990 Ω
2-35	1	9000 Ω (9 kΩ)
2-41	1	90 kΩ
2-54	1	200 kΩ
2-51	1	900 kΩ
2-237	1	1.8 megohm
2-52	1	9 megohm

PART No.	PARTS Per Kit	DESCRIPTION
CAPACITORS		
Disc		
(4)21-27	1	.005 μF
Tubular		
(5)23-91	1	.047 μF (1.6 kV)
(6)23-61	1	.05 μF
CONTROLS-SWITCHES		
(7)10-201	2	10 kΩ control
(8)10-229	1	2000 Ω control (2 kΩ)
10-78	1	15 kΩ control
(9)12-80	1	50 kΩ dual tandem control
(10)60-2	1	6-lug slide switch
(11)60-20	1	9-lug slide switch
(12)63-473	1	12-position rotary switch
TRANSISTORS-DIODES		
(13)417-118	4	2N3393 transistor (or equivalent)
(14)417-140	1	FET (field effect transistor)
(15)57-27	1	Silicon diode
SHIELDED CABLE-WIRE		
343-6	1	Shielded cable
341-1	1	Black test lead
341-2	1	Red test lead
344-50	1	Black hookup wire
344-52	1	Red hookup wire
344-59	1	White hookup wire

PART No.	PARTS Per Kit	DESCRIPTION
HARDWARE		
(16)250-52	6	4-40 x 1/4" screw
(17)254-9	6	#4 lockwasher
(18)252-2	6	4-40 nut
(19)250-229	4	6-32 x 1/4" phillips head screw
(20)253-10	4	Control flat washer
(21)254-4	3	Control lockwasher
(22)252-7	4	Control nut
MISCELLANEOUS		
(23)73-46	3	Plastic grommet
(24)214-66	1	1.5 V battery holder
(25)214-67	1	8.4 V battery holder
(26)260-1	1	Alligator clip
(27)436-20	1	Phone jack
439-1	1	Red test probe
439-2	1	Black test probe
(28)455-50	1	Knob bushing
(29)462-252	1	Pointer knob
407-129	1	Meter
85-197	1	Circuit board
(30)203-507	1	Panel
95-29	1	Plastic case
331-6		Solder
(31)490-5	1	Nut starter
391-34	1	Blue and white label
597-260	1	Parts order form
597-308	1	Kit Builders Guide
595-921	1	Manual

NOTE: The following batteries should be purchased at this time for use in the completed kit:

1 C-cell flashlight battery, NEDA 14

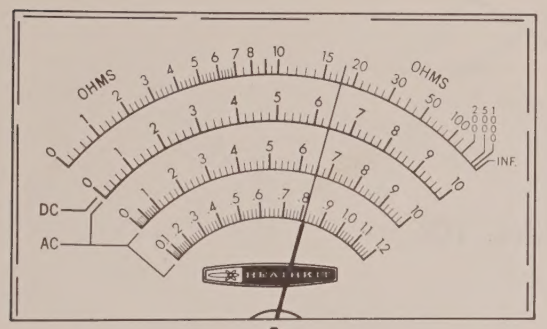
1 8.4 volt mercury battery, NEDA 1611

PARTS PICTORIAL

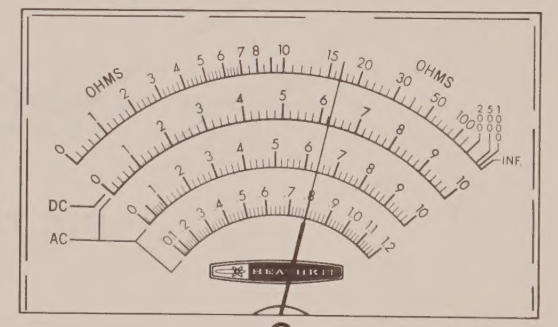
VOLTMETER USE CHART

REFERENCE	SELECTOR SWITCH	USE SCALE	SCALE READING	MULTIPLIER	ACTUAL VALUE VOLTS/OHMS	USE TEST LEAD*
A	DC VOLTS/1	Black 0-10	6.4	.1	.64 Volts	Gray
A	DC VOLTS/10	Black 0-10	6.4	1.	6.4 Volts	Gray
A	DC VOLTS/100	Black 0-10	6.4	10.	64. Volts	Gray
A	DC VOLTS/1000	Black 0-10	6.4	100.	640. Volts	Gray
B	AC VOLTS/1.2	Red 0-1.2	.64	1	.64 Volts	Red
C	AC VOLTS/10	Red 0-10	6.4	1	6.4 Volts	Red
A	AC VOLTS/100	Black 0-10	6.4	10	64. Volts	Red
A	AC VOLTS/1000	Black 0-10	6.4	100	640. Volts	Red
D	Rx1	Green OHMS	15	1	15 Ohms	Red
D	Rx100	Green OHMS	15	100	1,500 Ohms	Red
D	Rx10k	Green OHMS	15	10,000	150 kΩ**	Red
D	Rx1M	Green OHMS	15	1,000,000	15 megohm**	Red

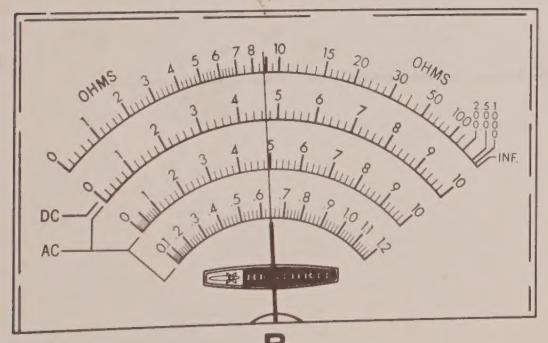
*In addition to the common (black) test lead.
**kΩ = kilohm (1,000 ohms).
megohm = 1,000,000 ohms.



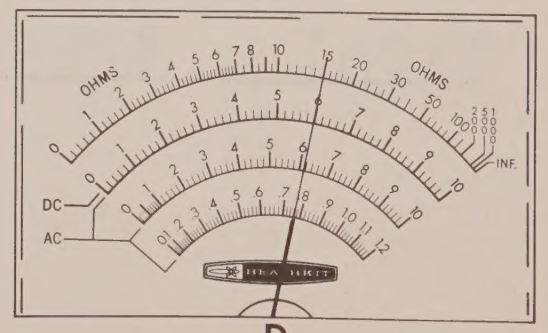
A



C



B



D

OPERATION

The power consumption of the Solid-State Voltmeter is very low and there is no objection to leaving the instrument turned on continuously during a series of measurements rather than turning it off each time a measurement function is completed. However, to prevent drain on the ohmmeter battery, do not leave the SELECTOR switch set in the OHMS position longer than is necessary to make resistance measurements.

The Voltmeter Use Chart (fold-out from this page) has been included to summarize the following instructions on using the Voltmeter.

NOTE: If you are not thoroughly familiar with the measurement of volts and resistance, refer to the Applications section on Page 32, for some practical ways to use the voltmeter.

SAFETY PRECAUTIONS

CAUTION: It is good practice to observe certain basic rules of operating procedure anytime voltage measurements are to be made. Always handle the test probe by the insulated housing only and do not touch the exposed tip portion.

When high voltage measurements are to be made, remove operating power to the unit under test before connecting the test leads. If this is not possible, be careful to avoid accidental contact with nearby objects which could provide a ground return path. When working on high voltage circuits, play safe. Keep one hand in your pocket to minimize accidental shock hazard and be sure to stand on a properly insulated floor or floor covering.

TEST LEADS

The black test lead with the alligator clip is the common, or negative, lead. It is usually connected to the chassis, or lower voltage point, when you are measuring DC voltage. When you measure AC voltage, or resistance, it can usually be connected to either side of the circuit.

The gray, shielded lead with the black probe is used (with the black test lead) to measure DC voltages only. Connect this lead to the positive (+) or the higher voltage point of the circuit.

The red test lead with the red probe is used (with the black lead) to measure both AC voltage and resistance. These leads are connected to the two sides of the circuit when measuring AC voltage. To measure resistance, connect the black lead to one side and the red lead to the other side of the circuit or device to be measured.

NOTE: If the resistance of a circuit is being measured, and that circuit contains diodes, transistors, or electrolytic capacitors, the test leads must be connected to the circuit correctly (with the test leads correctly polarized) or you will not obtain correct readings. For example, when there is a diode in the circuit, you may obtain two different resistance readings, depending on how you connect the test leads. The lower reading, which will include the forward resistance of the diode, will occur when the black test lead is connected near the cathode end of the diode. The higher reading, which will give the diode's back resistance, will occur when the black lead is connected near the anode of the diode.

MAKING MEASUREMENTS

Figure 5 shows the scales and markings on the face of the meter. Before making any voltage or resistance measurements with your Voltmeter, be sure to turn the POWER switch ON and check the zero position of the pointer with the POLARITY switch at DC+ and DC-. Turn the ZERO control, if necessary, to zero the meter.

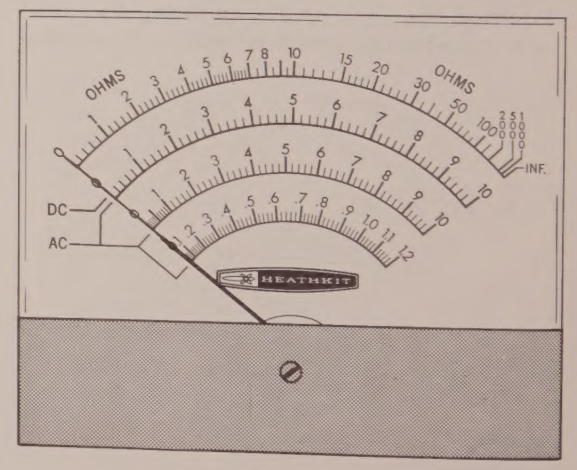
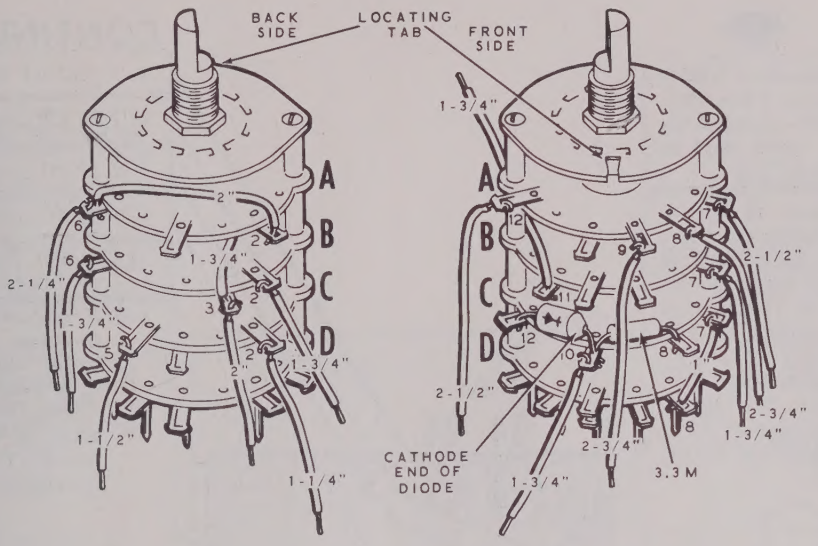


Figure 5



PICTORIAL 1

( ) Prepare the following lengths of white hookup wire:

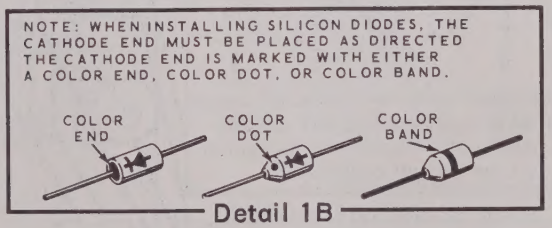
1-3/4"	2-3/4"
1"	2-3/4"
1-3/4"	2-1/2"
2-1/2"	

Connect one end of each of the following white wires to the rotary switch. Leave the other end free to be connected later unless the step directs otherwise. Position the ends as shown.

	WIRE LENGTH	FROM SWITCH LUG	TO
( )	1-3/4"	C10 (NS)	Not connected.
( )	1"	C7 (S-1)	D8 (S-1).
( )	1-3/4"	B7 (S-1)	Not connected.
( )	2-1/2"	A12 (S-1)	Not connected.
( )	2-3/4"	A9 (S-1)	Not connected.
( )	2-3/4"	A8 (S-1)	Not connected.
( )	2-1/2"	A7 (S-1)	Not connected.

( ) Connect a 3.3 megohm (orange-orange-green) resistor between lug C8 (S-1) and lug C10 (NS) of the rotary switch.

NOTE: Refer to Detail 1B to identify the cathode lead of the silicon diode to be installed in the next step.


NOTE: WHEN INSTALLING SILICON DIODES, THE CATHODE END MUST BE PLACED AS DIRECTED THE CATHODE END IS MARKED WITH EITHER A COLOR END, COLOR DOT, OR COLOR BAND.
COLOR END
COLOR DOT
COLOR BAND

Detail 1B

( ) Connect the cathode lead of the silicon diode to lug C10 (S-3) and the other lead to lug C12 (S-1) of the rotary switch.

Set the switch aside. It will be installed later.

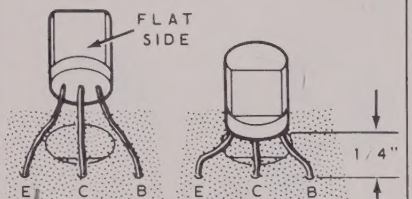
CIRCUIT BOARD ASSEMBLY

Position the circuit board lettered side up on your work surface as shown in Pictorial 2. Then complete each step on Pictorials 2 and 3.

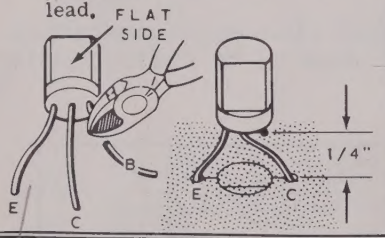
START

NOTE: Solder the mounting tabs of controls and the leads of the transistors and vertically-mounted tubular capacitor as each part is mounted.

( ) 2N3393 transistors at Q2 and Q3 (S-6). To identify the transistor leads, line up the flat side of the transistor with the flat outline drawn on the circuit board. Then insert the leads into their correct holes marked E, C, and B. Position the transistor about 1/4" above the circuit board. Trim off excess leads from the foil side of the board.



( ) Clip the B lead from each of the two remaining 2N3393 transistors. Then install these transistors at Q4 and Q5 (S-4). Trim excess leads on the foil side of the board. Be sure the cut stub of the B lead does not touch the C lead.



( ) 50 kΩ dual control (#12-80). Position the control as indicated on the circuit board (S-2).

( ) 10 kΩ control (#10-201) (S-4).

( ) 10 kΩ control (#10-201) (S-4).

( ) 9 kΩ (precision).

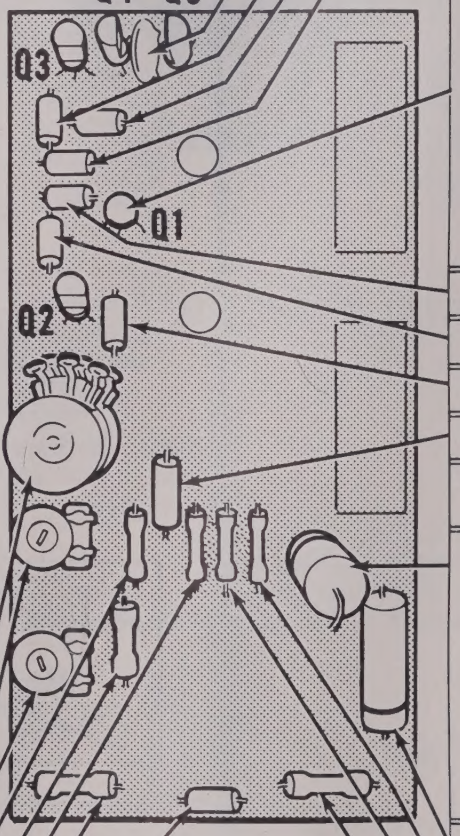
( ) 990 Ω (precision).

( ) 9 MΩ (precision).

( ) 200 kΩ (precision).

( ) 10 Ω (brown-black-black).

( ) Solder all connections and cut off the excess leads.



PICTORIAL 2

CONTINUE

( ) .005 μF disc capacitor.

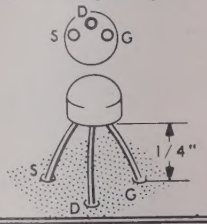
( ) 10 kΩ (brown-black-orange).

( ) 22 kΩ (red-red-orange).

( ) 33 kΩ (orange-orange-orange).

( ) Solder all connections and cut off the excess leads.

( ) F.E.T. (#417-140) (S-3). NOTE: Observe the location of the leads; then line them up with G, D, and S marked on the circuit board. Position the transistor about 1/4" above the circuit board. (The appearance of this transistor may vary).



( ) 22 kΩ (red-red-orange).

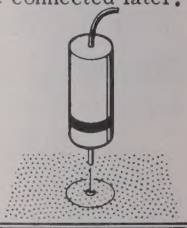
( ) 10 kΩ (brown-black-orange).

( ) 3.3 MΩ (orange-orange-green).

( ) 9.1 Ω (white-brown-gold) 2 watt.

( ) Solder all connections and cut off the excess leads.

( ) .047 μF 1600 V tubular (S-1). Note banded end. The other end will be connected later.



( ) .05 μF 400 V tubular. Position the banded end as shown.

( ) 90 kΩ (precision).

( ) 900 kΩ (precision).

( ) 1.8 MΩ (precision).

( ) Solder all connections and cut off the excess leads.

NOTE: You should have a 1 megohm resistor (brown-black-green) remaining. It will be used later.

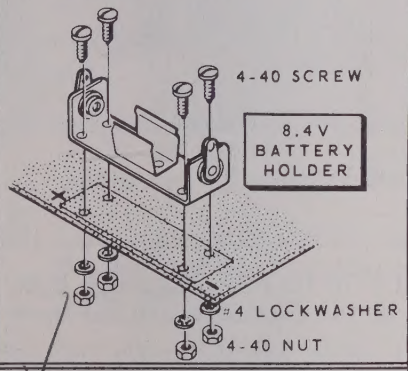
PROCEED TO PICTORIAL 3

START

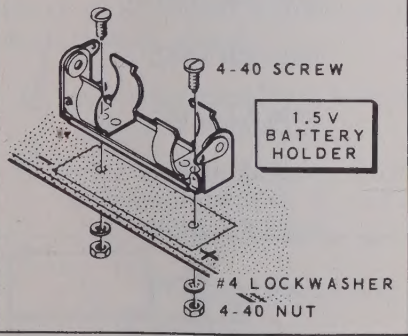
The plastic nut starter that is provided with this kit will help you pick up a nut and start it on the screw threads. Use the larger end for #4 nuts.

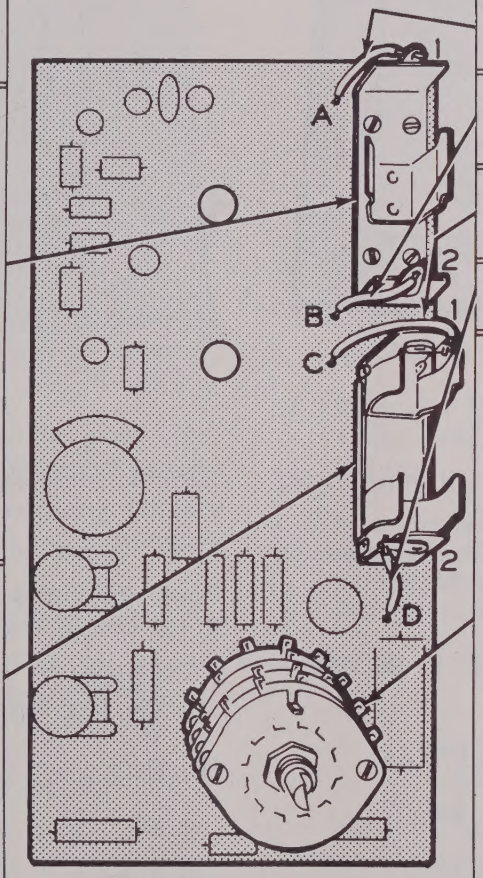
NOTE: When soldering battery holder connections, make sure that solder is confined to the point of connection.

( ) 8.4 V battery holder (#214-67). Position the battery holder as shown and mount it to the circuit board.



( ) 1.5 V battery holder (#214-66). Position the battery holder as shown and mount it to the circuit board. NOTE: It may be necessary to bend the negative solder lug to keep it from interfering with the vertically-mounted capacitor.





CONTINUE

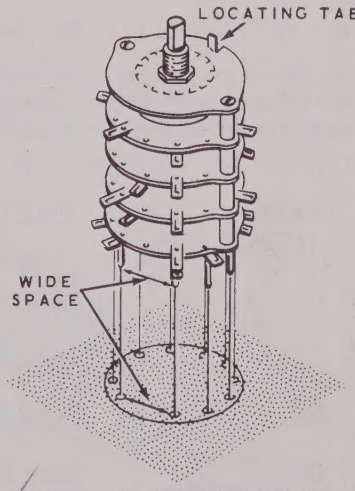
( ) 1-1/4" white wire from lug 1 (S-1) to circuit board hole A (S-1).

( ) 1-1/4" white wire from lug 2 (S-1) to circuit board hole B (S-1).

( ) 1-1/2" white wire from lug 1 (S-1) to circuit board hole C (S-1).

( ) 1" white wire from lug 2 (S-1) to circuit board hole D (S-1).

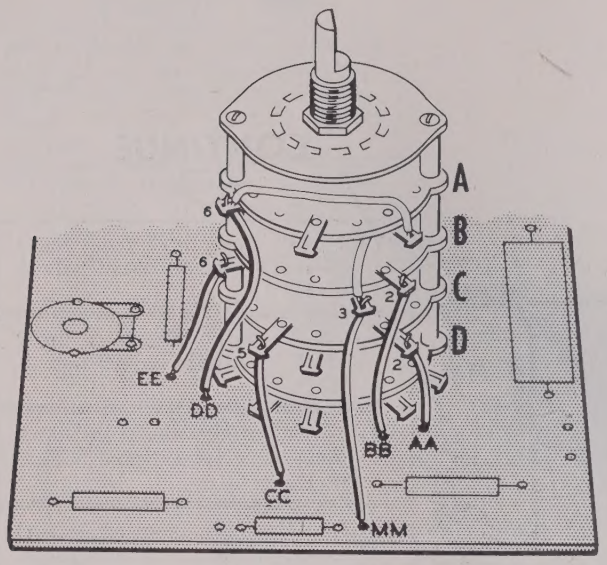
( ) Rotary switch (#63-473). NOTE: If any of the switch mounting lugs are bent, straighten them before installing the switch.



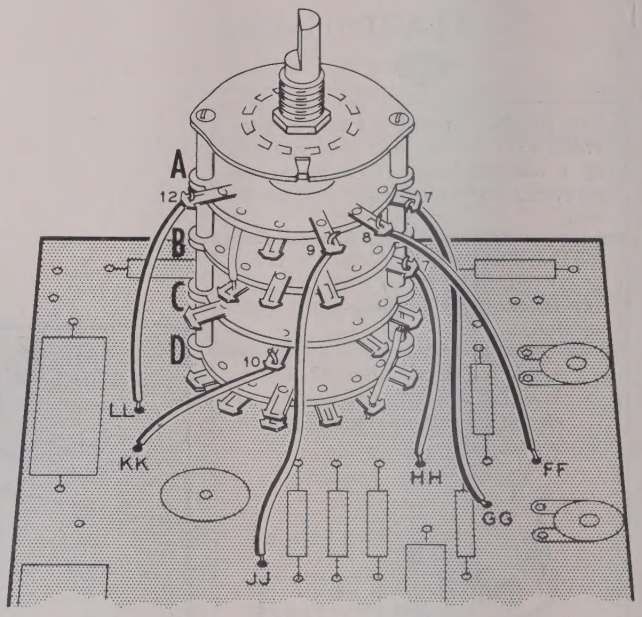
( ) Solder all switch pins to the foil. Do not cut off the soldered leads.

FINISH

PICTORIAL 3



PICTORIAL 4



PICTORIAL 5

Refer to Pictorial 4 for the following steps.

Place the wires coming from the rotary switch in the circuit board holes as follows:

	FROM SWITCH LUG	TO CIRCUIT BOARD
( )	C5	hole CC (NS).
( )	C2	hole AA (NS).
( )	B6	hole EE (NS).
( )	B3	hole MM (NS).
( )	B2	hole BB (NS).
( )	A6	hole DD (NS).

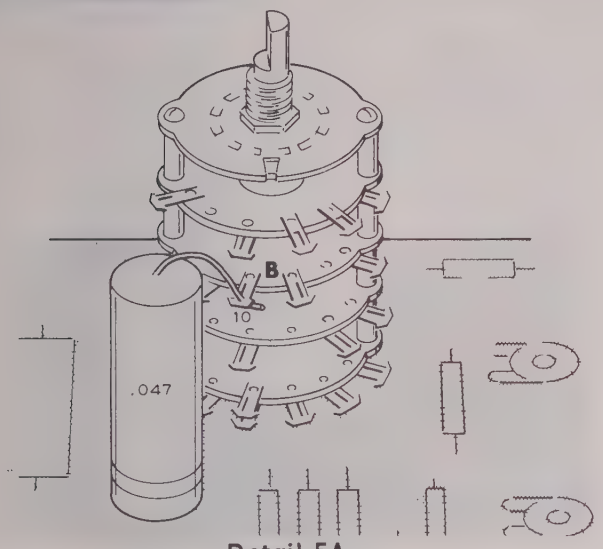
( ) Solder the 6 wires coming from the switch to the circuit board. Trim off any excess wire on the foil side of the board.

Refer to Pictorial 5 for the following steps. Note that the position of the circuit board has been reversed.

Place the wires coming from the rotary switch in the circuit board holes as follows:

	FROM SWITCH LUG	TO CIRCUIT BOARD
( )	C10	hole KK (NS).
( )	B7	hole HH (NS).
( )	A12	hole LL (NS).
( )	A9	hole JJ (NS).
( )	A8	hole FF (NS).
( )	A7	hole GG (NS).

( ) Solder the 6 wires coming from the switch to the circuit board. Trim off any excess wire on the foil side of the board.



Detail 5A

(✓) Refer to Detail 5A and connect the free lead of the .047 μF 1600 V capacitor on the circuit board to rotary switch lug B10 (S-1).

(✓) Make sure that no wires obstruct lugs A10, B9, A4, and C4, to which connections will be made later.

Set the circuit board aside for the present.

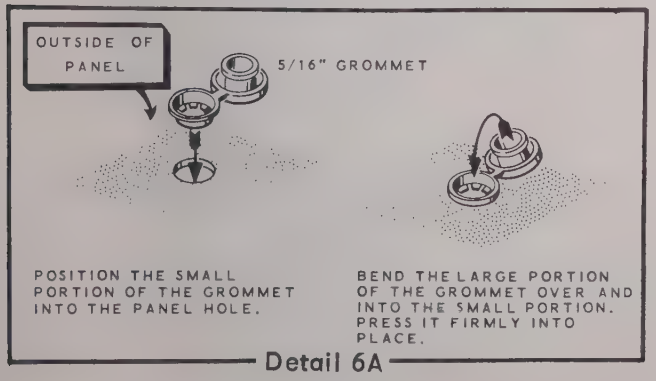
PANEL PARTS MOUNTING

NOTE: Place a soft cloth on your workbench or table to prevent marring the face of the panel during the following steps.

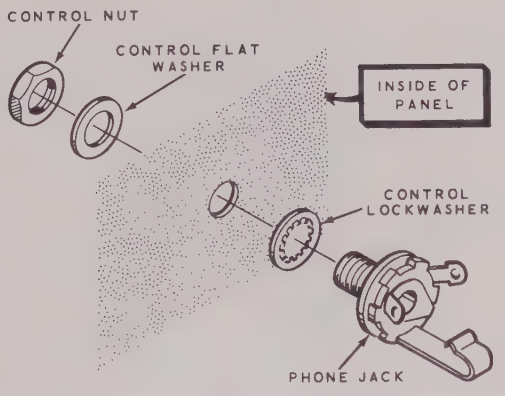
Refer to Pictorial 6 (fold-out from Page 4) for the following steps.

(✓) Locate the panel and position it on you work surface as shown.

(✓) Refer to Detail 6A, and mount the three plastic grommets at G, H, and J.


OUTSIDE OF PANEL
5/16" GROMMET
POSITION THE SMALL PORTION OF THE GROMMET INTO THE PANEL HOLE.
BEND THE LARGE PORTION OF THE GROMMET OVER AND INTO THE SMALL PORTION. PRESS IT FIRMLY INTO PLACE.

Detail 6A

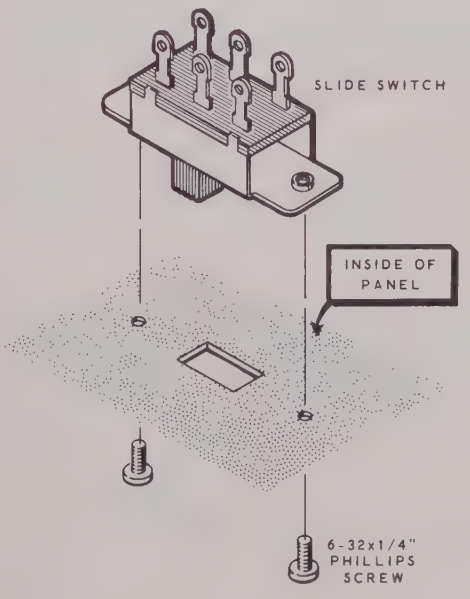


Detail 6B

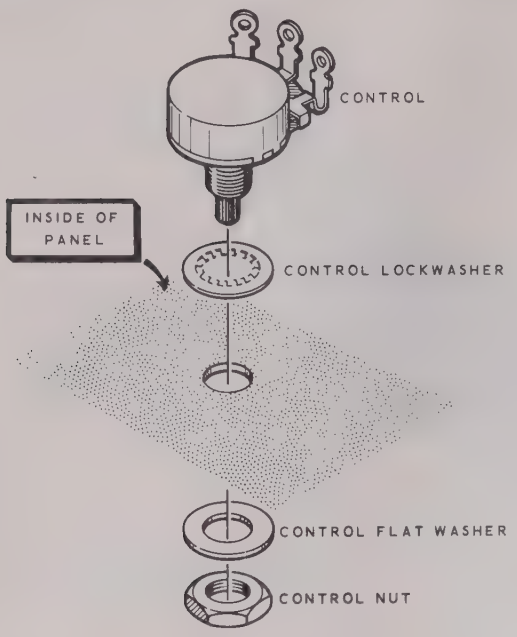
(✓) Refer to Detail 6B, and mount the phone jack at **F**. Use a control lockwasher, a control flat washer, and a control nut. Position the jack as shown.

(✓) Refer to Detail 6C, and mount the 6-lug slide switch at D using two 6-32 x 1/4" screws.

(✓) In a similar manner, mount the 9-lug slide switch at E using two 6-32 x 1/4" phillips screws. Position the wide space between the switch lugs as shown in the Pictorial.



Detail 6C



Detail 6D

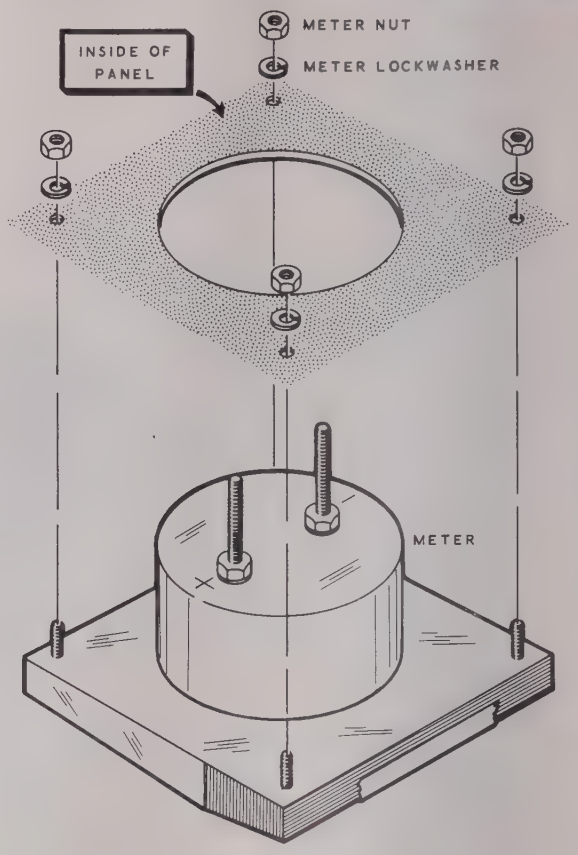
( ) Refer to Detail 6D, and mount the 15 kΩ control at A using a control lockwasher, a control flat washer, and a control nut. Position the control as shown.

( ) In a similar manner, mount the 2000 Ω (2 k) control at B using a control lockwasher, a control flat washer, and a control nut.

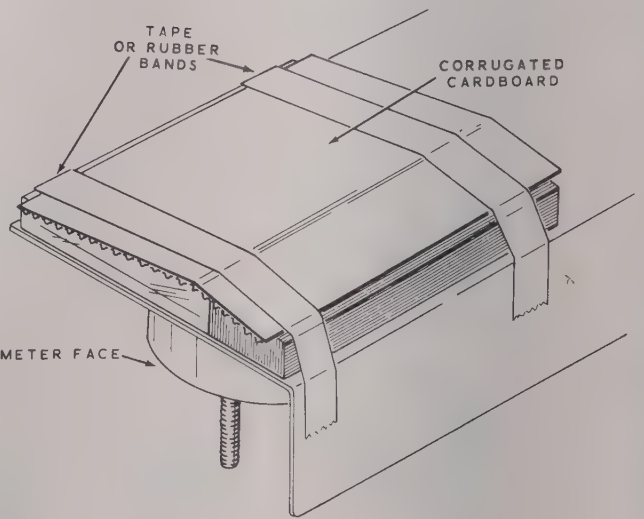
NOTE: The hardware necessary for mounting the meter is packaged with the meter and will be referred to as "meter hardware."

( ) Refer to Detail 6E, and mount the meter at C. Use the meter hardware. Save the remaining meter hardware for use later. Do not damage the plastic meter case by overtightening the nuts.

( ) Refer to Detail 6F, and tape a cardboard protector to the face of the meter.



Detail 6E



Detail 6F

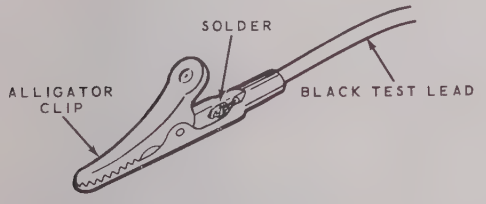
Detail 7A

PANEL WIRING

Refer to Pictorial 7 (fold-out from Page 4) for the following steps.

( ) Refer to Detail 7A, and prepare the red and black test leads.

( ) Refer to Detail 7B and solder an alligator clip to one end of the black test lead.



Detail 7B

( ) Insert the other end of the black test lead through grommet H, and tie a knot approximately 3" from this end of the lead.

Prepare the black test probe in the following manner.

( ) Cut a 5-1/2" length from the shielded cable and put it aside for later use.

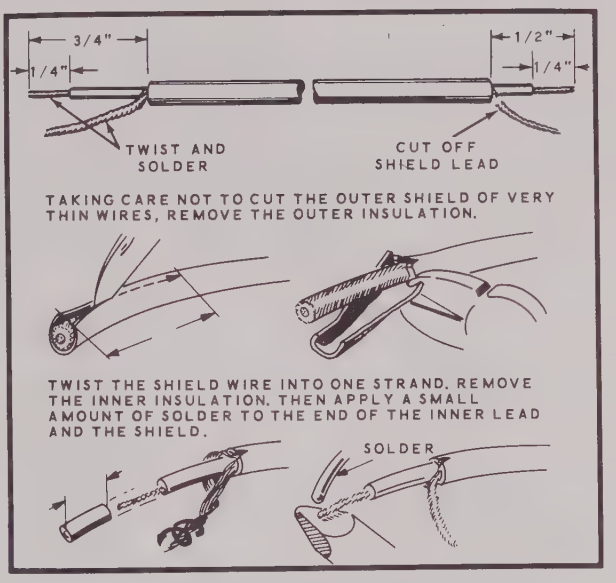
( ) Refer to Detail 7C, and prepare the remaining length of shielded cable.

Refer to Detail 7D for the following steps.

( ) Cut one lead of a 1 megohm (brown-black-green) resistor to a length of 3/8". Connect this lead to the end of the shielded cable without shielded lead (S-1).

( ) Disassemble the black probe.

( ) Insert the end of the cable with shielded lead through the black probe handle starting from the threaded end. Pull the cable until the resistor approaches the probe handle, as shown.


3/4"
1/4"
1/2"
1/4"
TWIST AND SOLDER
CUT OFF SHIELD LEAD
TAKING CARE NOT TO CUT THE OUTER SHIELD OF VERY THIN WIRES, REMOVE THE OUTER INSULATION.
TWIST THE SHIELD WIRE INTO ONE STRAND. REMOVE THE INNER INSULATION. THEN APPLY A SMALL AMOUNT OF SOLDER TO THE END OF THE INNER LEAD AND THE SHIELD.
SOLDER

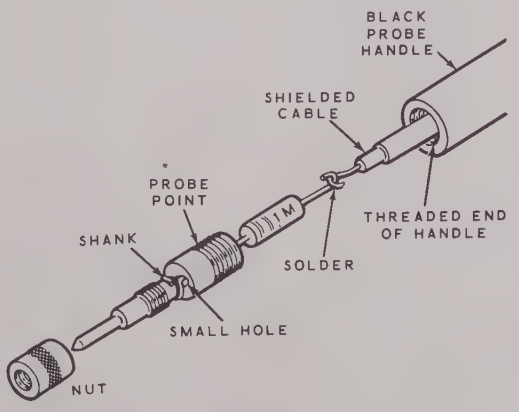
Detail 7C

( ) Cut the free end of the resistor to a length of 1/2". Insert this lead into the open end of the probe point so that approximately 1/4" extends out through the small hole. About half the length of the resistor will be inside the probe point.

( ) Wrap the resistor lead coming from the small hole around the shank as shown.

( ) Place the nut on the probe point and tighten it. This will hold the end of the resistor lead in place.

( ) Screw the black probe handle onto the probe point.



Detail 7D

( ) Insert the loose end of the shielded cable through grommet G, and tie a knot approximately 3 inches from this end of the cable.

( ) In a similar manner, install the red test probe on one end of the red test lead. No resistor is used, and the inner conductor of the red test lead is inserted directly into the small hole of the probe point.

( ) Wrap the wire lead coming from the small hole around the shank of the probe point.

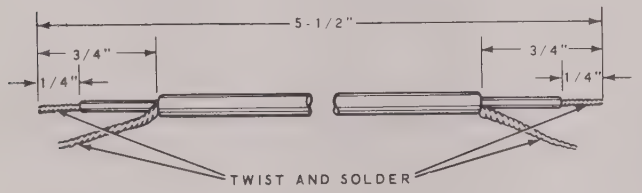
( ) Place the nut on the probe point and tighten it.

( ) Screw the red probe handle onto the probe point.

( ) Insert the other end of the red test lead through grommet J, and tie a knot approximately 6" from the end of the lead.

( ) Connect the inner lead of the shielded cable to lug 2 (NS), and the shield lead to lug 1 (NS), of phone jack F.

( ) Refer to Detail 7E, and prepare a 5-1/2" shielded cable as shown.



Detail 7E

( ) Connect the inner lead at one end of the 5-1/2" shielded cable to lug 2 (S-2), and the shield lead to lug 1 (S-2), of phone jack F. The other end will be connected later.

( ) Prepare the following lengths of hookup wire:

5-1/2" red
6-1/2" black
6" white

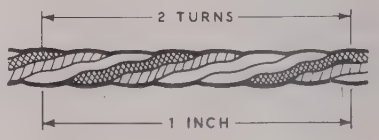
NOTE: many of the wires installed in the following steps will have only one end connected at this time. Their free ends will be connected later.

( ) Connect a 5-1/2" red wire to lug 3 of control B (S-1).

( ) Connect 6-1/2" black wire to lug 2 of control B (S-1).

( ) Connect 6" white wire to lug 1 of control B (S-1).

( ) Refer to Detail 7F, and twist together the three wires connected to control B. The wires should be twisted approximately two turns per inch.



Detail 7F

( ) Prepare the following lengths of hookup wire:

4" red
4" red
4-1/2" white
4-1/2" white
4" black
4" black

NOTE: You may find it easier to solder the lugs of slide switch E in the following steps if, before you connect the wires, you bend the outer rows of lugs outward slightly.

( ) Connect one end of a 4" red wire to lug 8 of slide switch E (S-1).

( ) Connect one end of a 4" red wire to lug 7 of slide switch E (S-1).

( ) Twist together the two red wires connected to slide switch E to form a twisted pair.

( ) Connect a 4-1/2" white wire to lug 5 of slide switch E (S-1).

( ) Connect a 4-1/2" white wire to lug 4 of slide switch E (S-1).

( ) Twist together the two white wires connected to slide switch E to form a twisted pair.

( ) Connect a 4" black wire to lug 3 of slide switch E (S-1).

( ) Connect a 4" black wire to lug 2 of slide switch E (S-1).

( ) Twist together the two black wires connected to slide switch E to form a twisted pair.

( ) Prepare the following lengths of hookup wire:

1" red
1" black
3-1/2" red
3-1/2" black
3-1/2" black
4-3/4" white

( ) Connect a 1" red wire between lugs 3 (S-1) and 4 (NS) of slide switch D.

( ) Connect a 1" black wire between lugs 1 (NS) and 6 (S-1) of slide switch D.

( ) Connect a 3-1/2" red wire to lug 4 of slide switch D (S-2).

( ) Connect a 3-1/2" black wire to lug 1 of slide switch D (S-2).

( ) Twist together the red from lug 4 and black wire from lug 1 of slide switch D.

( ) Connect a 3-1/2" black wire to lug 5 of slide switch D (S-1).

( ) Connect a 4-3/4" white wire to lug 2 of slide switch D (S-1).

( ) Twist together the black wire from lug 5 and white wire from lug 2 of slide switch D.

CIRCUIT BOARD WIRING

Refer to Pictorial 8 (fold-out from this Page) for the following steps.

( ) Prepare the following lengths of hookup wire:

1" white
1-1/4" white
3" red
3" black

( ) Connect a 1" length of white wire from lug 5 of the Bias Adj control (S-1) to circuit board hole M (S-1).

( ) Connect a 1-1/4" length of white wire from lug 1 of the Bias Adj control (S-1) to circuit board hole L (S-1).

( ) Connect one end of a 3" red wire to hole F in the circuit board (S-1).

( ) Connect one end of a 3" black wire to hole E in the circuit board (S-1).

( ) Twist these two wires together to form a twisted pair. Position them as shown.

( ) Connect the free end of the black test lead to circuit board hole K (S-1).

Connect the twisted wires from control B as follows:

( ) Red wire to lug 2 on the Bias Adj control (S-1).

( ) White wire to lug 6 on the Bias Adj control (S-1).

( ) Black wire to circuit board hole N (S-1).

Connect the wires from switch E to the circuit board as follows:

( ) Either white wire to hole P (S-1), and the other white wire to hole R (S-1).

( ) Either black wire to hole T (S-1), and the other black wire to hole S (S-1).

( ) Either red wire to hole W (S-1), and the other red wire to hole U (S-1).

( ) Connect the loose end of the red test lead to lug B9F of the rotary switch (S-1).

Connect the red and black twisted pair from slide switch D as follows:

( ) Red wire to circuit board hole J (S-1).

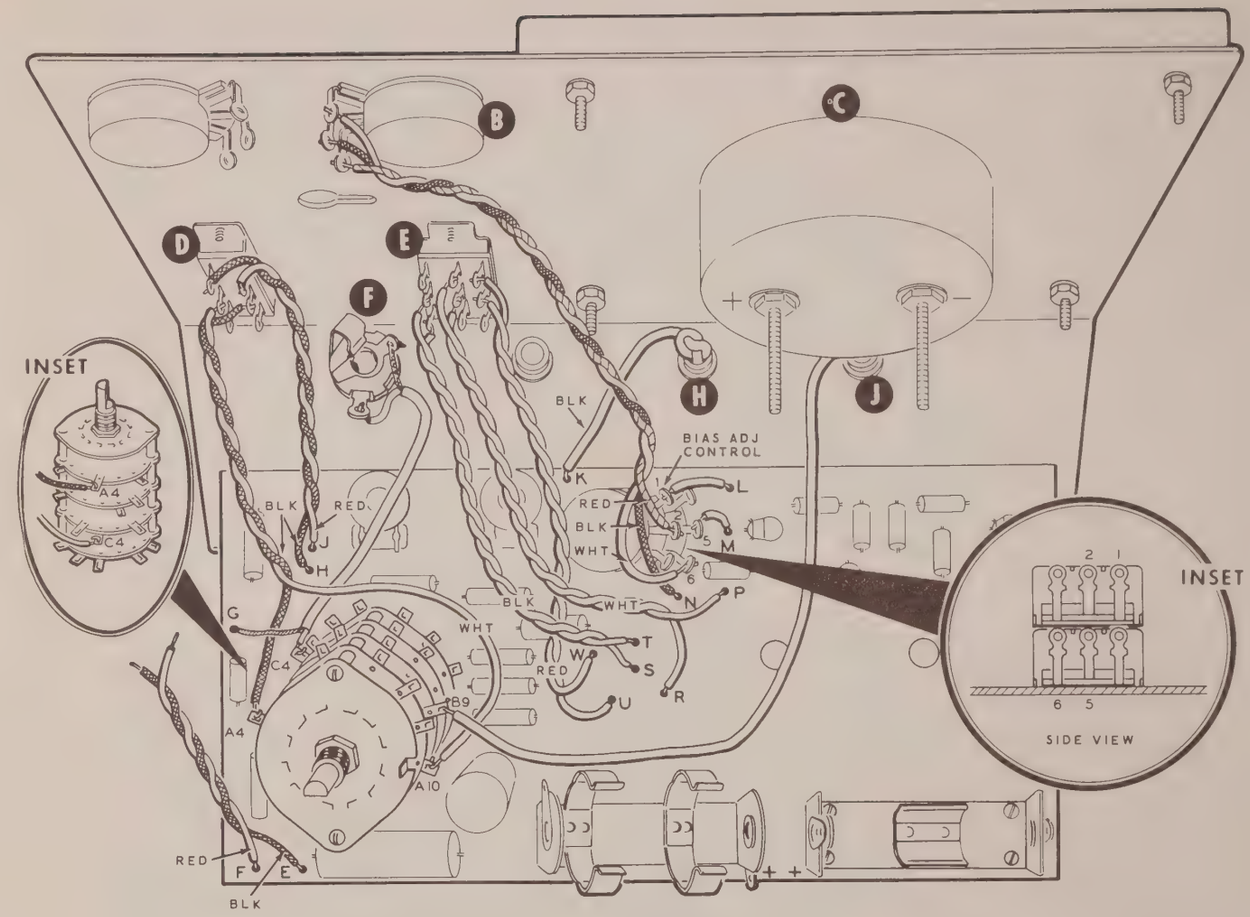
( ) Black wire to circuit board hole H (S-1).

Connect the black and white twisted pair from slide switch D to the rotary switch as follows:

( ) White wire to lug A10 (S-1).

( ) Black wire to lug A4 (S-1).

( ) Connect the inner lead of the 5-1/2" shielded cable from phone jack F to lug C4 of the rotary switch (S-1), and the shield to circuit board hole G (S-1).



PICTORIAL 8

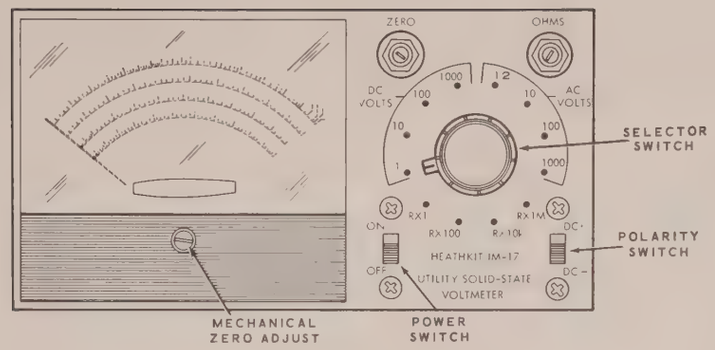


FIGURE 1

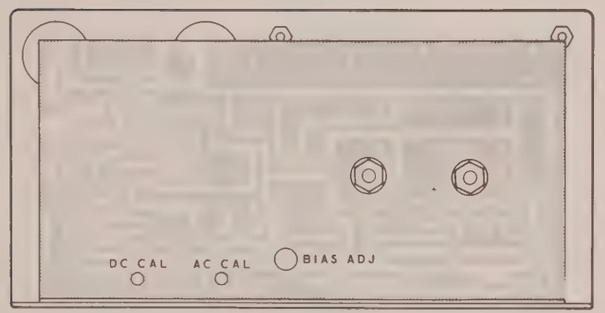
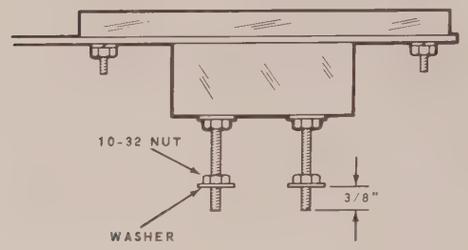


FIGURE 2

FINAL WIRING

Refer to Pictorial 9 for the following steps.

( ) Refer to Detail 9A and thread a meter nut onto each meter stud. Then place a meter washer on each stud.



Detail 9A

( ) Position the circuit board so the rotary switch shaft extends through its hole in the panel and the meter studs extend through the circuit board holes.

( ) Adjust the two meter nuts so the circuit board is parallel to the front panel as shown in the inset drawing on the Pictorial.

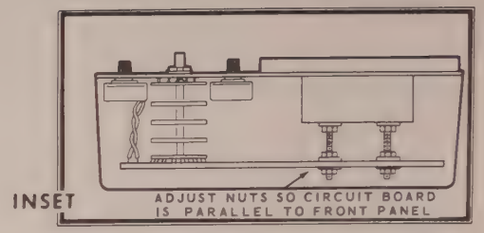
( ) Place a meter lockwasher and a meter nut on each of the two studs extending from the circuit board. Leave the nuts loose.

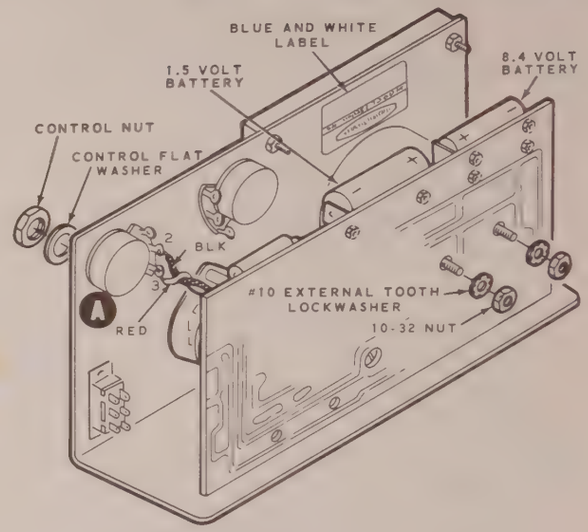
( ) Secure the rotary switch to the panel. Use a control flat washer and a control nut.

( ) Tighten the nuts on the meter studs. CAUTION: Do not overtighten the nuts as the circuit board can be damaged.

( ) Connect the red wire from hole F of the circuit board to lug 3 of control A (S-1).

( ) Connect the black wire from hole E of the circuit board to lug 2 of control A (S-1).





PICTORIAL 9

Refer to Detail 9B for the following steps.

( ) Press the knob bushing onto the shaft. Note the location of the spring.

( ) Rotate the shaft of the rotary switch so its flat side is in the exact position shown.

( ) Position the knob with the pointer directed towards 1 in the DC Volts range and press the knob firmly onto the knob bushing.

( ) Carefully remove the knob bushing and knob together.

(✓) Place the knob on a hard surface; then press the knob bushing firmly into the knob. Use a soft cloth on the work surface to avoid scratching the knob.

(✓) Press the knob and bushing firmly onto the switch shaft.

(✓) Make sure the white index line of the knob points to 1 in the DC Volts range.

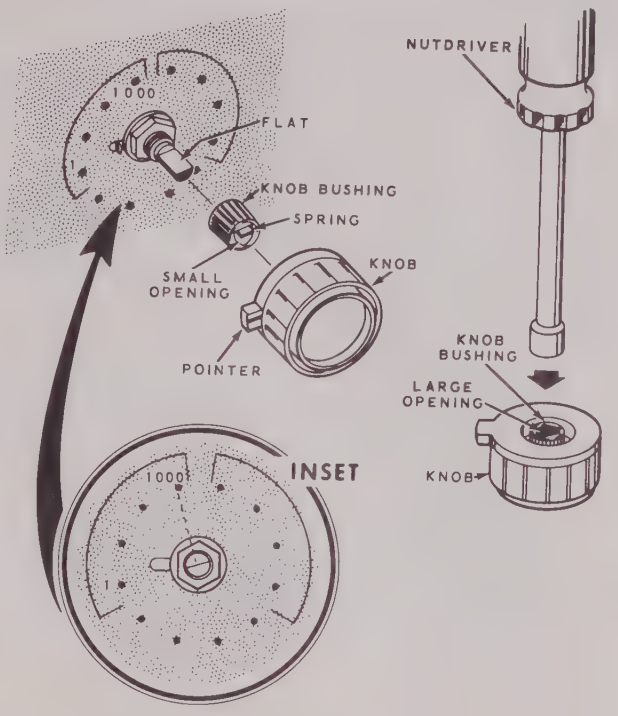
NOTE: The blue and white label that is installed in the next step shows the Model number and Production Series number of your kit. Refer to these numbers in all communications with the Heath Company; this assures you that you will receive the most complete and up-to-date information in return.

(✓) Remove the cardboard protector from the meter face.

(✓) Remove the backing from the blue and white label and press the label onto the chassis as shown in Pictorial 9.

(✓) Check to see that all connections are soldered and that no solder bridges exist between foils on the circuit board. Shake out any solder splashes or wire clippings.

This completes the assembly of the Voltmeter except for the case which is installed later.



Detail 9B

CALIBRATION

Refer to Figure 1 and 2 (fold-out from Page 14) for the following steps.

NOTE: If the Voltmeter does not seem to operate properly during any of the following tests, turn it off immediately and refer to In Case Of Difficulty on Page 23.

(✓) Turn the mechanical zero-adjust screw at the bottom of the meter until the meter pointer is directly over the zero indication on the meter face.

( ) Set the Voltmeter switches and controls as follows:

SELECTOR SWITCH:	DC VOLTS/1000
POLARITY:	DC+
POWER:	OFF
ZERO:	Center of rotation.
BIAS ADJ (on circuit board):	Maximum counter-clockwise.
DC CAL (on circuit board):	Maximum counter-clockwise.
AC CAL (on circuit board):	Maximum counter-clockwise.

(✓) Install the batteries as shown in Pictorial 9. Match the + markings on the batteries to the + markings screened on the circuit board.

ELECTRICAL ZERO ADJUSTMENT

( ) Turn POWER switch to ON and adjust the BIAS ADJ control for an approximately zero meter reading.

( ) Turn the ZERO control fully clockwise. This should result in an upscale meter reading.

( ) Readjust ZERO control for a zero indication on the meter.

( ) Alternate the POLARITY switch between DC+ and DC-. If the meter needle was set exactly on zero, it should remain on zero in either switch position.

( ) Set the POLARITY switch to DC- and turn the ZERO control fully counterclockwise. This should cause the meter pointer to move upscale. Readjust the ZERO control for a zero indication on the meter.

DC CALIBRATION

( ) Set the POLARITY switch to DC+.

( ) Turn the SELECTOR switch to DC VOLTS/ 10.

( ) Touch the tip of the DC probe (black) to the positive terminal of the 1.5 V battery and adjust the DC CAL control (on circuit board) for a 1.5 volt meter indication on the black scale, as shown in Figure 3. (If other DC voltages that are known to be more accurate are available, they may be used to further check the DC Calibration.)

( ) Remove the probe tip from the battery and readjust the ZERO control for a zero indication on the meter. Then repeat the previous step.

AC CALIBRATION

CAUTION: Use extreme care when measuring line voltages. Personal shock or instrument damage could result from carelessness.

( ) Turn the SELECTOR switch to AC VOLTS/ 1000 and set the POWER switch to ON.

( ) Connect the AC-ohms test leads (black lead and red lead) across the AC line. You can do this most conveniently if you first attach the alligator clip on the black lead to the metal shank of a screwdriver. Then insert the blade of the screwdriver into one of the slotted openings in an electric wall outlet. TAKE CARE NOT TO TOUCH THE TIP OF THE RED PROBE TO THE SCREWDRIVER, and carefully insert the tip of the red probe into the remaining opening in the wall outlet.

( ) Adjust the AC CAL control (on the circuit board) for a meter reading of 120 volts on the black scale (this is a reading of 1.2, or one scale division above the numeral 1, as shown in Figure 4). If the line voltage is known to be other than 120 volts, adjust for this value.

( ) Disconnect the test leads from the AC line.

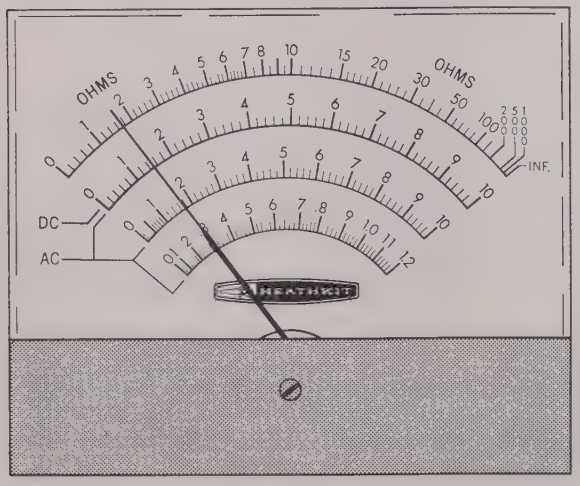


Figure 3

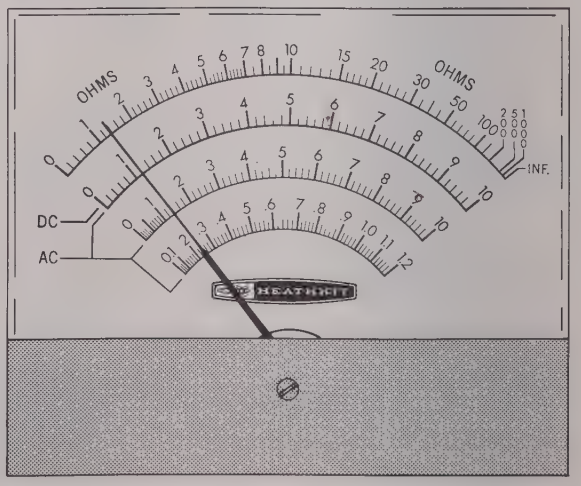


Figure 4

OHMS ADJUSTMENT

( ) Turn the SELECTOR switch to Rx1M. The meter should give an up-scale reading.

( ) Adjust the OHMS control for a full scale (INF) reading on the green scale.

( ) Touch the tips of the AC-ohms test leads (the red probe and the alligator clip) together; this should cause a zero meter reading. If it does not, turn the ZERO control (with the leads touching) to zero the meter needle. Then separate the leads and repeat the preceding step and this step.

( ) Turn the SELECTOR switch to each of the other three resistance ranges. Each range should give a zero indication with the AC-ohms test leads touching each other, and an INF reading with these test leads apart. On the Rx1 range, with the leads touching, observe that there will be a fraction of an ohm circuit resistance.

FINAL BIAS ADJUSTMENT

( ) Turn the SELECTOR switch to one of the DC VOLTS positions.

( ) Turn the ZERO control fully clockwise.

( ) Adjust the BIAS ADJ control for a reading of 1 on the black 0-10 scale.

( ) Turn the ZERO control for a "O" meter reading. NOTE: This setting of the BIAS ADJ control should allow for future adjustments to "O" as the battery voltage decreases over a period of time. When "O" cannot be reached by adjusting the ZERO control, the BIAS ADJ may be reset without disturbing the calibration.

( ) Turn the POWER switch to OFF.

This completes the Calibration.

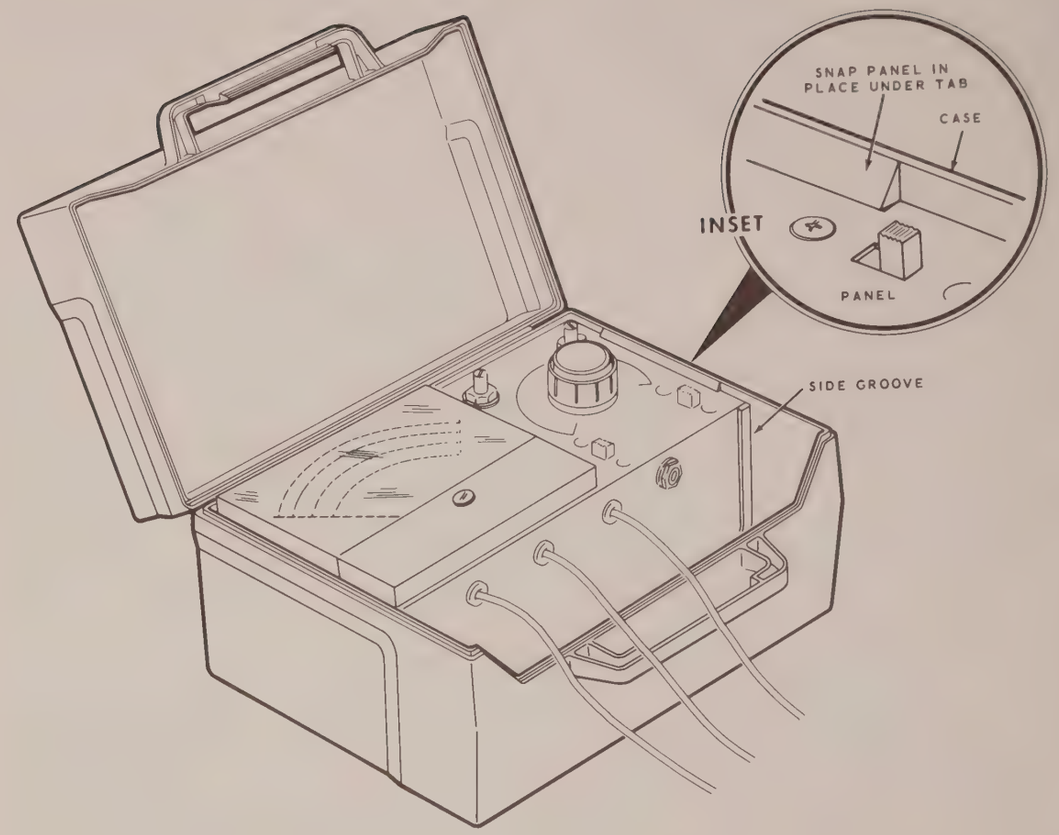
FINAL ASSEMBLY

Refer to Pictorial 10 for the following steps.

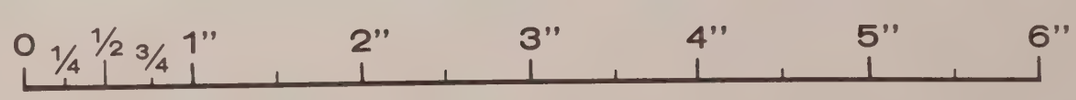
( ) Make sure that all three cables hang out from the front of the panel.

( ) Position the case as shown in the Pictorial with the shorter (vertical) edges of the panel aligned with the grooves in the sides of the case. Press the front panel down, making sure that the tabs on the sides of the case snap over the edges of the front panel as shown in the inset drawing.

This completes the assembly of your Voltmeter.



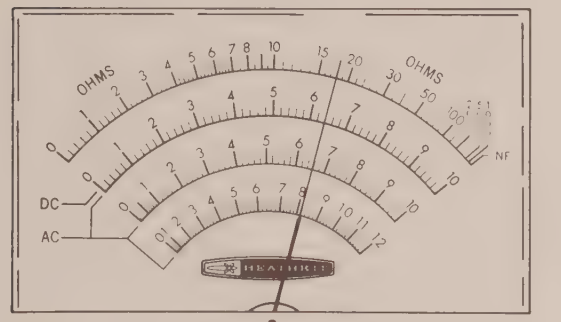
PICTORIAL 10



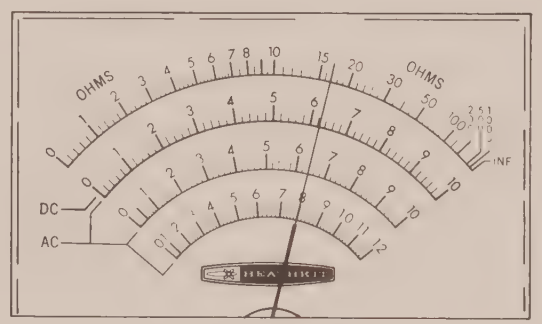
VOLTMETER USE CHART

REFERENCE	SELECTOR SWITCH	USE SCALE	SCALE READING	MULTIPLIER	ACTUAL VALUE VOLTS/OHMS	USE TEST LEAD*
A	DC VOLTS/1	Black 0-10	6.4	.1	.64 Volts	Gray
A	DC VOLTS/10	Black 0-10	6.4	1.	6.4 Volts	Gray
A	DC VOLTS/100	Black 0-10	6.4	10.	64. Volts	Gray
A	DC VOLTS/1000	Black 0-10	6.4	100.	640. Volts	Gray
B	AC VOLTS/1.2	Red 0-1.2	.64	1	.64 Volts	Red
C	AC VOLTS/10	Red 0-10	6.4	1	6.4 Volts	Red
A	AC VOLTS/100	Black 0-10	6.4	10	64. Volts	Red
A	AC VOLTS/1000	Black 0-10	6.4	100	640. Volts	Red
D	Rx1	Green OHMS	15	1	15 Ohms	Red
D	Rx100	Green OHMS	15	100	1,500 Ohms	Red
D	Rx10k	Green OHMS	15	10,000	150 kΩ**	Red
D	Rx1M	Green OHMS	15	1,000,000	15 megohm**	Red

*In addition to the common (black) test lead.
**kΩ = kilohm (1,000 ohms).
megohm = 1,000,000 ohms.



A



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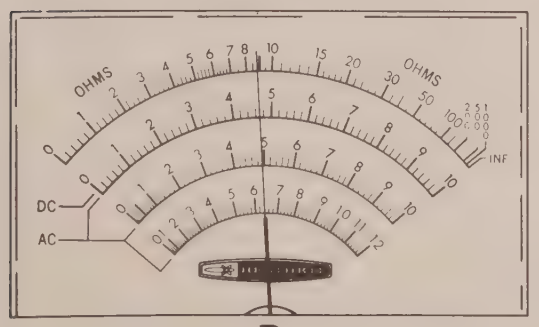

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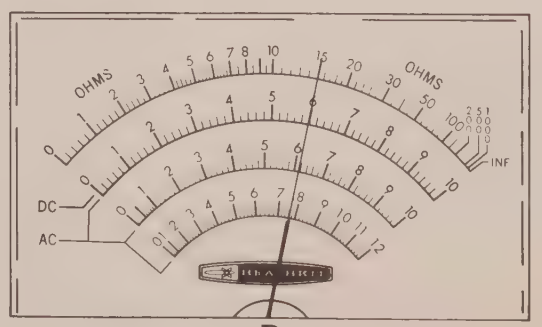


D

OPERATION

The power consumption of the Solid-State Voltmeter is very low and there is no objection to leaving the instrument turned on continuously during a series of measurements rather than turning it off each time a measurement function is completed. However, to prevent drain on the ohmmeter battery, do not leave the SELECTOR switch set in the OHMS position longer than is necessary to make resistance measurements.

The Voltmeter Use Chart (fold-out from this page) has been included to summarize the following instructions on using the Voltmeter.

NOTE: If you are not thoroughly familiar with the measurement of volts and resistance, refer to the Applications section on Page 32, for some practical ways to use the voltmeter.

SAFETY PRECAUTIONS

CAUTION: It is good practice to observe certain basic rules of operating procedure anytime voltage measurements are to be made. Always handle the test probe by the insulated housing only and do not touch the exposed tip portion.

When high voltage measurements are to be made, remove operating power to the unit under test before connecting the test leads. If this is not possible, be careful to avoid accidental contact with nearby objects which could provide a ground return path. When working on high voltage circuits, play safe. Keep one hand in your pocket to minimize accidental shock hazard and be sure to stand on a properly insulated floor or floor covering.

TEST LEADS

The black test lead with the alligator clip is the common, or negative, lead. It is usually connected to the chassis, or lower voltage point, when you are measuring DC voltage. When you measure AC voltage, or resistance, it can usually be connected to either side of the circuit.

The gray, shielded lead with the black probe is used (with the black test lead) to measure DC voltages only. Connect this lead to the positive (+) or the higher voltage point of the circuit.

The red test lead with the red probe is used (with the black lead) to measure both AC voltage and resistance. These leads are connected to the two sides of the circuit when measuring AC voltage. To measure resistance, connect the black lead to one side and the red lead to the other side of the circuit or device to be measured.

NOTE: If the resistance of a circuit is being measured, and that circuit contains diodes, transistors, or electrolytic capacitors, the test leads must be connected to the circuit correctly (with the test leads correctly polarized) or you will not obtain correct readings. For example, when there is a diode in the circuit, you may obtain two different resistance readings, depending on how you connect the test leads. The lower reading, which will include the forward resistance of the diode, will occur when the black test lead is connected near the cathode end of the diode. The higher reading, which will give the diode's back resistance, will occur when the black lead is connected near the anode of the diode.

MAKING MEASUREMENTS

Figure 5 shows the scales and markings on the face of the meter. Before making any voltage or resistance measurements with your Voltmeter, be sure to turn the POWER switch ON and check the zero position of the pointer with the POLARITY switch at DC+ and DC-. Turn the ZERO control, if necessary, to zero the meter.

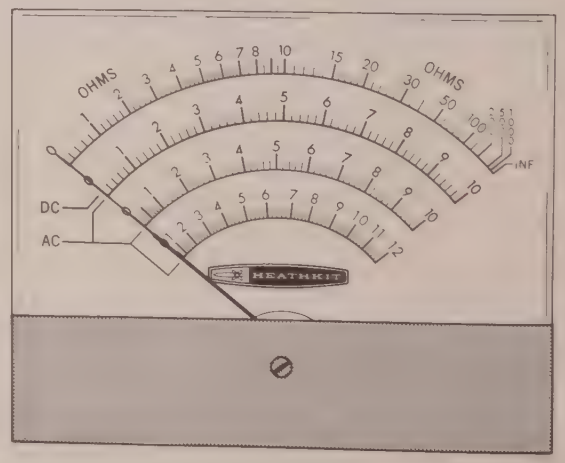


Figure 5

CAUTION: When measuring voltage, always set the SELECTOR switch to a range greater than the voltage to be measured, if an approximate voltage is known. If the voltage is completely unknown, set the SELECTOR switch to 1000 and connect the test leads to the circuit to be measured. Then momentarily turn the power on. If the meter moves less than 1/10 of full scale, switch to the next lower range. The maximum voltage that can be safely measured with your Voltmeter is 1000 volts, and this limit must not be exceeded.

RESISTANCE (OHMS) READINGS

CAUTION: Before attaching the test leads for resistance measurements, make sure there is no power on the circuit and that all large capacitors have been discharged.

The SELECTOR switch must be at one of the green Rx positions when making resistance measurements. Make sure the connectors on the test leads are not touching, and turn the OHMS control until the pointer rests over the last green mark (INF) at the right-hand end of the Ohms scale. Do not change the setting of the ZERO control while making resistance measurements.

Resistance is measured by connecting the black test lead and the red test lead to the two ends of the unknown resistance. When using the two middle ranges, if the reading on the green ohms scale is under 1 or over 100, change the SELECTOR switch setting.

A reading of 0 on the Rx1 scale indicates a short circuit, or that the circuit is continuous. A reading of INF (infinity) on the Rx1M scale indicates an open circuit, or a resistance so large that it cannot easily be measured.

The figures on the green Ohms scale are multiplied by 1, 100, 10,000 (10 k), or 1,000,000 (1M), according to the setting of the SELECTOR switch. When this switch is in the Rx100 position, for example, a reading of 6 would indicate 600 ohms, or a reading of 50 would indicate 5000 ohms.

The Rx10k position indicates that the meter scale should be multiplied by 10,000. The last counterclockwise position of the OHMS range switch is marked Rx1M. M means megohm, or 1,000,000 ohms, so the meter reading would be multiplied by 1,000,000.

NOTE: Some ohmmeter battery current is drawn whenever the instrument is turned ON and the SELECTOR switch is in one of the Rx positions. To save battery life when you are not using the ohmmeter, NEVER LEAVE THE SELECTOR SWITCH IN THE OHMS POSITION.

DC Voltage Readings

To measure DC voltage, turn the Voltmeter ON. Use the gray lead with the black probe, and the black lead. The switch can be at DC+ or DC-, depending on whether a positive or a negative voltage is to be applied to the probe tip. This is convenient when measuring voltages at several points in a circuit, some positive and some negative with respect to a common point. The common test lead may remain connected to the common voltage point, and the SELECTOR switch changed to DC+ or DC- for the appropriate polarity.

DC voltages are read on the black meter scale marked 0-10. The markings on the SELECTOR switch refer to the voltage that will give a full-scale reading on the black scale when measuring DC voltage.

The lowest DC VOLTS switch position is marked 1. This means that 1 volt applied to the probe tip will cause a full-scale deflection of the meter pointer, or indicate 10 on the scale. To read voltage in the 1 volt range, read the black 0-10 scale and move the decimal one place to the left. For example, a reading of 2 would indicate .2 volt.

To read voltage on the 10 volt range, read the black 0-10 scale directly.

For the 100 volt range, read the black 0-10 scale and move the decimal one place to the right. For example, a meter reading of 4 would indicate a measurement of 40 volts.

On the 1000 V range, read the black 0-10 scale and move the decimal two places to the right. For example, a meter reading of 3 would indicate 300 volts.

AC VOLTAGE READINGS

To measure AC voltage, first make sure the power is turned off in the circuit to be measured. Set the SELECTOR switch to one of the AC VOLTS ranges and turn the Voltmeter to ON. Connect the red test lead to one side of the circuit to be measured, and the black test lead to the other side. Then apply power to the circuit.

NOTE: If it is known which wire is the neutral, or common, side of the circuit, the black lead is customarily attached to this point.

The lowest AC VOLTS switch position is marked 1.2 in red. Voltages in this range are read directly on the red 1.2 scale.

When the SELECTOR switch is on the red 10 volt range, read the 0-10 red scale directly.

Use the black 0-10 scale when the SELECTOR switch is on the 100 and the 1000 ranges. To read voltage on the 100 range, read the black scale and move the decimal one place to the right. For example, a reading of 6 would indicate 60 volts.

On the 1000 volt range, read the black scale and move the decimal two places to the right. For example, a reading of 5 would indicate 500 volts.

VOLTMETER CHARACTERISTICS

DC Voltage Measurements

The Solid-State Voltmeter has many advantages over the nonelectronic voltmeter. The greatest advantage is its ability to measure voltages without significantly loading the circuit being tested. This characteristic enables the voltage to be measured more accurately. This is especially desirable in such high impedance circuits as resistance coupled amplifiers and AVC (automatic volume control) networks, and on oscillator grids.

To illustrate this advantage of the Solid-State Voltmeter, assume that a resistance-coupled audio amplifier with a 500 k ohm plate load resistor is operating from a 100 volt plate source. See Figure 6.

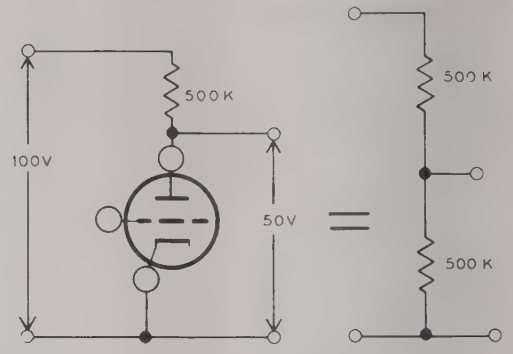


Figure 6

Assuming that the actual plate voltage in this case is 50 volts, the tube therefore acts as a 500 k ohm resistor. When measuring the plate voltage with a conventional 1000 ohms-per-volt meter on the 100 volt scale, the meter represents a 100 k ohm resistor placed in parallel with the tube. See Figure 7. The voltage on the plate, as shown on the meter, would then be 14.3 volts. This large amount of error is caused by the shunt resistance of the meter.

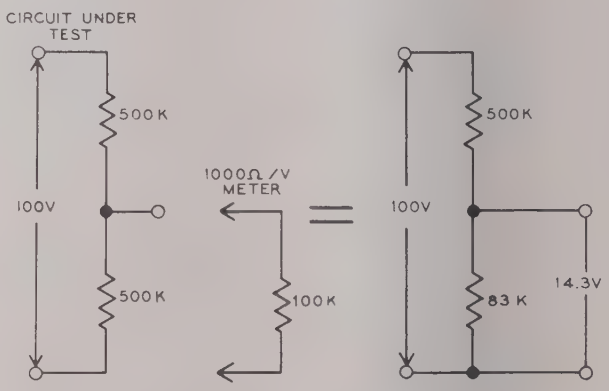


Figure 7

When the Solid-State Voltmeter is used on any scale, the full 11 megohms input resistance is placed in parallel with the tube. See Figure 8. A plate voltage of about 49 volts is then shown on the meter; only 2% lower than the normal operating voltage. Thus more accurate readings in this instance can be obtained only with a high resistance instrument such as the Solid-State Voltmeter.

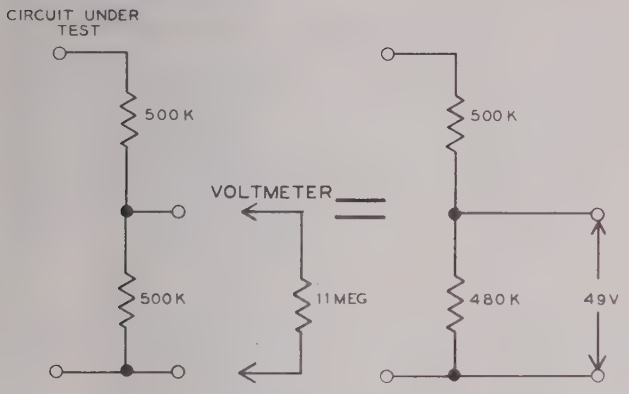


Figure 8

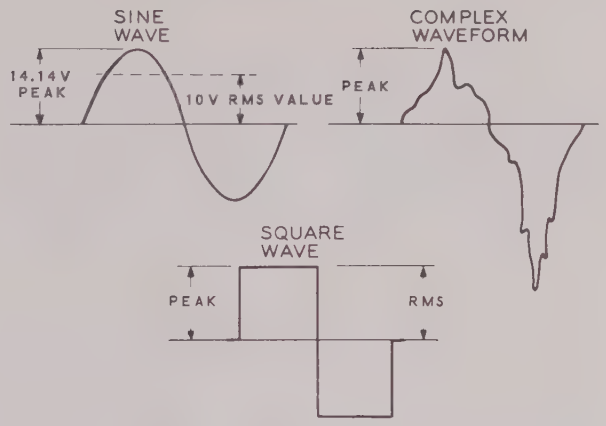


Figure 9

The one volt DC range is very useful when working with fractional voltages in solid state circuits. In this range, scale markings are provided every .02 volt, and you can, in addition, interpolate between marks.

AC Voltage Measurements

The Heathkit Solid-State Voltmeter is a very sensitive electronic AC voltmeter and, since the human body picks up AC when near any AC wires, the meter will indicate this pickup. Never touch the tip of the probe when the SELECTOR switch is set to the lower voltage ranges. Zero should be set with the probe shorted to the common clip, using the DC+ and DC- positions of the POLARITY switch.

The AC meter scales on the Solid-State Voltmeter are calibrated to read the rms (root-mean-square) value of a pure sine wave. The rms value for a sine wave voltage is .707 times the peak voltage. For complex waveforms, such as square waves, sawtooth waves or pulses, this ratio does not necessarily hold true. The complex waveform in Figure 9, for example, shows a spike that may be several times as large (peak value) as the rms value.

Since the spike is of short duration, the rms value of the overall waveform is barely affected. On the other hand, the square wave would present an rms value equal to the peak value. This voltmeter responds only to the positive peaks of AC voltages. Therefore, when measuring non-symmetrical waveforms, a reversal of the test leads may give a different reading.

When connecting the Voltmeter to the circuit under test, the Voltmeter input resistance and input capacitance are effectively placed in parallel with the voltage source. In some cases, this can load the circuit and change the actual voltage to be measured. At low frequencies of 50 or 60 Hz, the effects of capacitive loading may usually be disregarded. Thus, the load the Voltmeter presents to the circuit being measured is about the same as a 1 megohm resistor. At higher frequencies, the capacitive reactance decreases.

The amount of loading presented by the input capacitance and resistance of the Voltmeter is determined by the impedance of the circuit being tested. In low impedance circuits, such as 50 to 600 ohm, no noticeable error is introduced in the voltage reading through circuit loading. These circuits will only begin to be loaded at frequencies that approach the upper limit of the Solid-State Voltmeter's frequency response.

Remember, as a general rule, that frequency response and loading may affect the accuracy of your voltage readings. There will be a resistive loading of 1 megohm regardless of frequency. The amount of capacitive loading will depend on the frequency involved. The actual capacitance of the instrument and the leads may also affect the tuning of low capacitance resonant circuits.

You should know the values in the circuit under test and the values of the input resistance and capacitance of the Voltmeter. This will permit you to make valid readings over a wide range of impedances within the full frequency response of the instrument.

ACCURACY

The accuracy of measurements made with this Voltmeter depends on the accuracy of its calibration and the tolerance of the components used in its circuits. If the Voltmeter is carefully calibrated with precision standards, then the worst case of error would be the sum of component tolerances.

The meter movement is accurate to within ±2 percent of full scale. On DC, the ±1 percent accuracy of the divider resistors must be considered, resulting in an accuracy within ±3 percent of full scale. On AC, the rectifier circuit contributes variations which could result in a maximum error of ±5 percent of full scale.

The accuracy on the OHMS ranges depends primarily on the multipliers, which are 1%, and the meter movement accuracy of 2%. Because of the nonlinear OHMS scale, the resulting accuracy is not readily expressed in a percentage figure.

NOTE: When comparing this instrument with another voltmeter, consider that the error of the other instrument may be in the opposite direction. Therefore, when comparing two instruments of ±5% accuracy, the total difference may be ±10%. Critical comparisons should only be made against certified laboratory standards.

TRANSPORTING THE METER

Be sure to place the POWER switch in the OFF position when the meter is being carried or transported. This not only avoids battery drain, but shorts the meter terminals together, which has a "damping" effect and protects the meter movement from damage which might be caused by sudden shocks (such as dropping).

NOTE: An Applications section is included in this Manual to provide those who do not have an electronic background with a few basic applications.

MAINTENANCE

METER

Because of the delicate nature of the meter movement, no attempt should be made to repair the meter. Such attempts would automatically void the standard warranty coverage of the meter itself.

BATTERY REPLACEMENT

NOTE: Before you decide that batteries should be replaced, refer to the Final Bias Adjustment procedure on Page 17.

Replace battery E1 (1.5V) whenever you cannot adjust the meter needle to the INF mark on the green scale in any range of RESISTANCE by use of the OHMS control.

Replace battery E2 (8.4V) whenever you cannot adjust the meter needle to 0 on any scale by use of the ZERO control.

ELECTROSTATIC CHARGE

The clear plastic meter cover has been treated to resist an accumulation of static electricity. However, should a static charge accumulate through repeated polishing or cleaning of the meter cover, the pointer will deflect in an erratic manner, regardless of whether the instrument is turned off or on. This condition can be corrected quickly. Apply a small quantity of liquid dishwashing detergent to a clean, soft cloth and wipe the surface of the meter cover. The accumulated electrostatic charge will immediately disappear. It is not necessary to remove the cover for this correction.

CHECKING METER COIL CONTINUITY

If you suspect the meter coil has failed, you can check the continuity of the coil with another ohmmeter as follows. (NOTE: Never check the continuity of the meter coil directly with another ohmmeter. The amount of current that would be drawn could seriously overload and probably ruin

the meter coil.) Always use a limiting resistor with a value of at least 10,000 Ω in series with the other ohmmeter test leads. The value of the resistor will depend upon the ohmmeter battery voltage and the range on which the ohmmeter is being used. NOTE: If a Heath Model IM-25 Solid-State Voltmeter is available, it can be used to check the meter coil directly because of the low voltage and current used.

TEST LEADS

Because of their constant flexing during use, the test leads are not above suspicion, especially after the Voltmeter has been in use for several years. Erratic or improper DC voltage measurements can sometimes be caused by a fault in the shielded test lead or phone plug or in the connections in the test probe.

ACCESSORY PROBES

HIGH VOLTAGE TEST PROBE

A high voltage test probe is available from the Heath Company. This probe will permit the Voltmeter to measure DC up to 30,000 volts, which covers the range of flyback power supply voltages commonly encountered in TV receivers. This probe consists of a red molded housing with a black molded handle. It contains a 2% precision 1090 megohm resistor and provides a DC range multiplication factor of 100 for 11 megohm input voltmeters.

RF TEST PROBE

An RF test probe is available from the Heath Company. This probe will permit the Voltmeter to be used for RF measurements up to 30 volts; its response is substantially flat from 1000 Hz to 100 MHz. A built-in isolating capacitor permits a DC voltage range of up to 500 volts. It uses a printed circuit board for easy assembly and its housing is of polished aluminum with polystyrene insulation.

NOTE: The accessory probes are connected to the Voltmeter through the phone jack on the surface of the panel near the test leads.

IN CASE OF DIFFICULTY

This section of the Manual is divided into three parts: Visual Test, Precautions for Troubleshooting, and the Troubleshooting Chart. Begin your search for any troubles that occur after assembly by carefully following the checks listed in the Visual Tests section. After Visual Tests are completed, refer to the Troubleshooting Chart. Refer to the Service and Warranty sections of the Kit Builders Guide in cases when you are unable to resolve the difficulty. If the Voltmeter is returned to the Heath Company, be sure all parts are included.

NOTE: Refer to the Circuit Board X-Ray View and Panel Photograph (on Pages 29 and 30) for the locations of parts on the circuit board and panel.

VISUAL TESTS

1. Recheck the wiring. Check for pinched wires. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the kit builder.

2. About 90% of the kits that are returned to the Heath Company for repair do not function properly due to poor connections and soldering and to solder "bridges" between foils. Therefore, many troubles can be eliminated by reheating all connections to make sure they are soldered as described in the Soldering section of the Kit Builders Guide.

3. Check to be sure that all transistors are in their proper locations. Make sure each transistor lead is connected to the proper point.

4. Check the values of the parts. Be sure in each step that the proper part has been wired into the circuit, as shown in the Pictorial diagrams. It would be easy for example, to install a 33 kΩ (orange-orange-orange) resistor where a 33 megohm (orange-orange-green) resistor should have been installed, or a 900 kΩ precision resistor instead of a 90 kΩ.

5. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring.

If the trouble is still not located after the visual tests are completed, and another voltmeter is available, check the voltage readings against those shown on the Schematic Diagram. NOTE: All voltage readings were taken with an 11 megohm input electronic voltmeter. Voltages may vary as much as ±20%.

NOTE: A review of the Circuit Description may help you determine where the trouble is.

PRECAUTIONS FOR TROUBLESHOOTING

1. Be cautious when testing transistor circuits that you do not operate the transistors beyond their limits. Although the transistors have almost unlimited life when used properly, they are much more vulnerable to damage from excessive voltage or current than tubes. A vacuum tube, for instance, can often be operated under shorted, zero-bias, excessive-voltage, or high-current conditions for short periods of time without materially damaging the tube, but any one of these same conditions can completely destroy a transistor instantly.

2. Be sure you do not cause any short circuits when making voltage measurements. This would almost certainly cause damage to one or more transistors or diodes.

3. Transistors should be inserted or removed only while the Voltmeter is turned off. If this rule is not followed, transistors may be damaged.

4. Do not operate the instrument with any of the transistors removed, as the resulting imbalance could damage the remaining transistors or the meter.

Troubleshooting Chart

SYMPTOM	POSSIBLE CAUSE
Completely inoperative.	1. Dead battery or poor battery contacts. 2. Transistors Q1, Q2, or Q3 defective. 3. Meter coil open.
Zero control has no effect.	1. Bias control R16 and R17 misadjusted. 2. Transistor Q1 defective. 3. Resistor on voltage divider string R5 through R9 and R12 open. 4. Zero control R15 open or shorted.
Inaccurate DC readings.	1. DC Calibration control R18 misadjusted. 2. Wrong value or defective resistor in voltage divider string R5 through R9 and R11.
AC (only) Inoperative.	1. Diode D1 defective. 2. Capacitors C1 (open) or C2 (shorted). 3. Resistor R4 open.
AC Inoperative. (1000 volt range only).	1. Resistor R2 open or resistor R3 shorted.
Inaccurate AC reading.	1. AC Calibration control R19 misadjusted.
Ohmmeter inoperative or inaccurate readings.	1. Battery E1 low voltage. 2. Transistor Q1 defective. 3. Resistors in voltage divider string R4 through R9 or R12 open or shorted.
Zero shift with leads shorted when turning Function switch through ohmmeter ranges.	1. Transistor Q1 defective.
Unable to reach 0 meter reading on any scale.	1. Readjust bias. 2. Replace battery E1 (1.5V).
Unable to reach INF on any resistance range.	1. Readjust bias. 2. Replace battery E2 (8.4V).

SPECIFICATIONS

DC VOLTMETER

Ranges	0-1, 0-10, 0-100, 0-1000 volts full scale.
Input Resistance	11 megohms on all ranges.
Accuracy	±3% of full scale.

AC VOLTMETER

Ranges	0-1.2, 0-10, 0-100, 0-1000 volts full scale.
Input Resistance	1 megohm on all ranges.
Input Capacitance	Approximately 100 pF (38 pF on 1000 V range).
Accuracy	±5% of full scale.
Frequency Response	±1 dB 10 Hz to 1 MHz (from low source impedance).

GENERAL

Ohmmeter Ranges	Rx1, Rx100, Rx10k, Rx1M.
Ohms Circuit Power Supply	1.5 volts (C-Cell, NEDA #14).
Amplifier Circuit Power Supply	8.4 volt Mercury Cell (NEDA #1611).
Meter	4-1/4", 200 μA, 100 degree movement.
Transistor-Diode Complement	1 - FET (field effect transistor).
	4 - silicon transistors (2N3393, or equivalent).
	1 - silicon diode.
Dimensions	8-1/2" wide x 4-1/4" high x 7-1/4" deep.
Net Weight	2-1/2 lbs.

The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

CIRCUIT DESCRIPTION

The Selector switch of the Voltmeter is used to select the correct circuit and desired range for each type of measurement. The AC-ohms test lead and the DC test probe are both connected to the switch, and the common test lead is connected to the circuit ground. This ground includes the ground foil of the circuit board, which is connected through the wiring to the panel.

DC

Isolation resistor R1 is in the DC Volts circuit for all DC Volts measurements. The DC Volts circuit includes a series of precision resistors (R5-R11) arranged as a voltage divider. The Selector switch connects the amount of resistance required for a specific range. The selected portion of the voltage is applied to the gate (G) of FET (field effect transistor) Q1, the DC input source follower. The FET provides isolation between the input voltage divider and the balanced bridge circuit. Because of the FET's high input impedance and low output impedance, it couples the DC input to the balanced bridge circuit without loading the voltage divider. The output of the FET is applied to the base of Q2, which is part of a balanced, emitter follower, current amplifier (Q2 and Q3).

AC

With the Selector switch in one of the AC Volts ranges, the test voltage is applied across voltage divider R2 and R3 to insure that on higher AC voltage ranges, no more than 100 volts appears at the anode of AC rectifier D1. At the AC rectifier, the test voltage is changed to a DC voltage which is proportional to the applied AC test voltage. Capacitor C2 is used at the output of the AC rectifier to hold the applied pulsating DC voltage at its peak value, so that the Voltmeter responds to the positive peak voltage regardless of the test voltage waveform.

The rectified AC test voltage is applied through AC isolation resistor R4 to a voltage divider, consisting of R5, R6, R7, R8, R9, and R11, where a portion of the rectified AC test voltage is selected and applied to the output circuits as previously described for the DC voltage measurement.

OHMS

The ohmmeter section of the Voltmeter uses 1.5 volt battery E1 connected in series with the voltage divider network (R5, R6, R7, R8, R9, and R12) and the resistance to be measured. The ratio between the ohmmeter voltage divider network resistors and the resistance being measured determines the portion of the ohmmeter battery voltage that is applied to the output circuits as previously described for the DC voltage measurement.

METER

For all measurement functions, a voltage is applied to the gate of the FET and its balanced bridge circuit. In each instance, this voltage is dependent upon the voltage or resistance being measured. When there is zero voltage at the input of the balanced bridge circuit, transistors Q2 and Q3 draw the same amount of emitter current; therefore, each emitter is at the same potential and the meter connected between them will not deflect.

When a positive voltage is applied to Q2, it draws more current than Q3, causing a difference in emitter potential between these two transistors. Since the meter is connected between the two emitters, a current then flows through the meter movement. The meter pointer responds proportionally to this current, indicating the value of the voltage or resistance being measured. The DC+ and DC- switch positions are used to reverse the meter connections between the emitters so that both positive and negative DC voltages can be measured without reversing the test leads.

The meter terminals are shorted together by the Power switch in its OFF position. This protects the meter movement from damage due to sudden shocks.

BATTERIES

The 8.4 volt battery supplies the operating voltage to Q1, Q2, and Q3. Any change in the battery

potential will affect the conduction of Q2 and Q3 equally and therefore will not affect the difference in emitter potential. The maximum conduction characteristics of Q2 and Q3, as used in this Voltmeter circuit, is such that the voltage applied to the meter terminals will not be large enough to damage the meter movement. This is one of the primary advantages of this type of circuit. The meter movement cannot be burned out by inadvertently measuring a voltage that is higher than the Selector switch setting. However, if excessive voltage is applied, the pointer may be bent as it hits against the stop. Caution must also be exercised to avoid applying any test voltage to the test probe when the Selector switch is set in the Ohms position.

Battery E1 is connected into the circuit when the Selector switch is in any of the Rx positions. It provides enough current for a full-scale meter indication. Avoid needless battery drain by placing the switch in one of the volts positions when resistance measurements are not being made.

FUNCTIONAL PARTS LIST

R1 - Isolation resistor in DC probe.

R2, R3 - Input voltage divider for AC. Divides the input voltage of the highest AC range so that no more than 100 volts appears at the anode of D1.

R4 - Isolation resistor for AC. Voltage dropping resistor.

R5 - R12 - DC voltage dividers: R5-R9 and R11. AC voltage dividers: R5-R9 and R11. Ohms voltage dividers: R5-R9 and R12.

R13 - Current limiter for the protection of Q1 (and Q4, Q5). Acts with C3 as a low pass filter to prevent AC from reaching the gate of Q1.

R14, R15, R16 - Voltage divider across the power supply. Determines the bias to the gate of Q1 (the meter needle is adjusted to 0 by R14, the panel Zero control).

R17 - Source resistor for Q1.

R18 - Variable resistance in series with the meter for DC calibration. Mounted on the circuit board.

R19 - Variable resistance in series with the meter for AC calibration. Mounted on the circuit board.

R21 - Variable resistance in series with the meter for Ohms full-scale calibration. Mounted on the panel.

R22, R23 - Emitter (load) resistors for Q2 and Q3.

R24, R25 - Voltage divider across the power supply to provide proper bias voltage to the base of Q3.

C1 - Input coupling capacitor. Blocks DC while passing AC to the input AC divider (R2 and R3).

C2 - Charges with the rectified AC from D1.

C3 - Acts with R13 as a low-pass filter to prevent AC from reaching the gate of Q1.

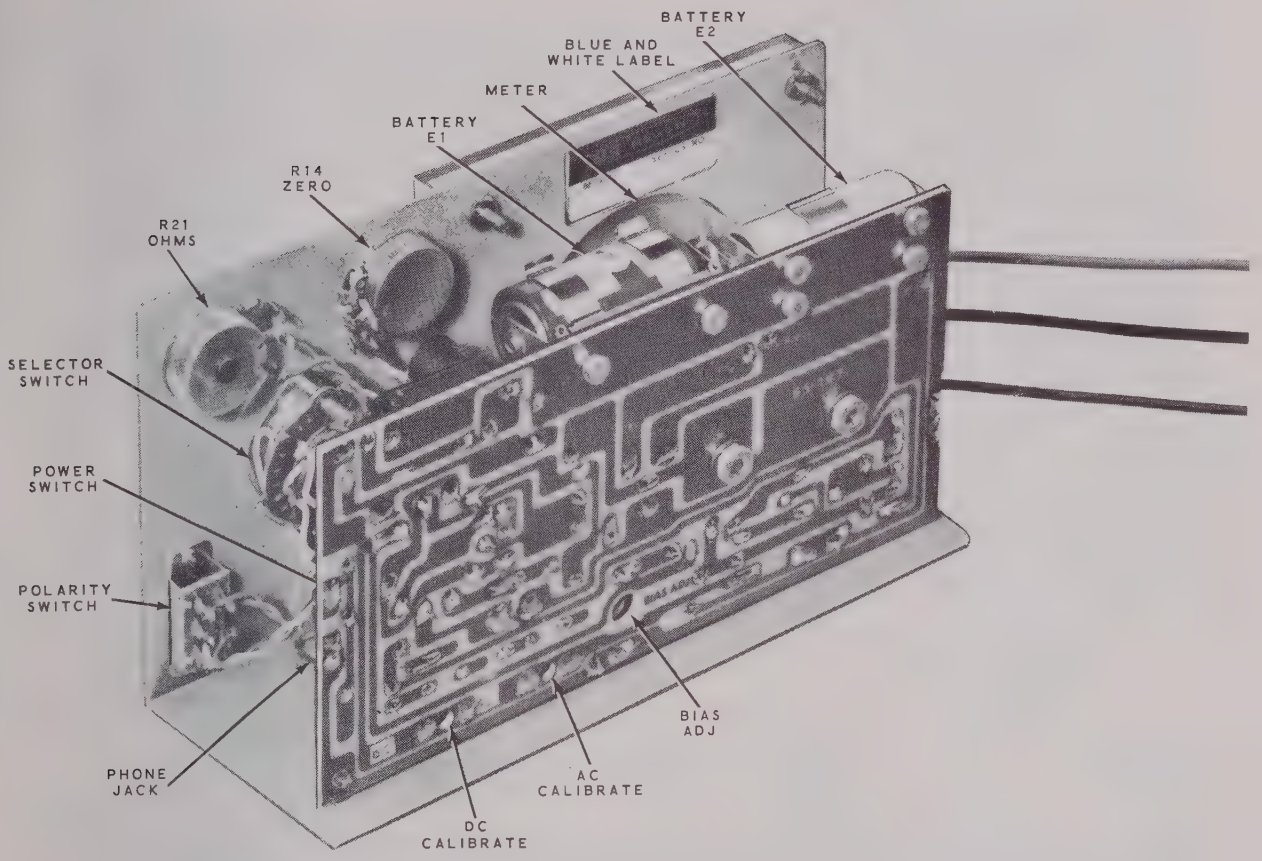
D1 - Diode rectifier to convert AC input voltages to DC.

Q1 - FET DC input source follower. Provides isolation between the input dividers (R5-R11) and the output circuit. Provides high input impedance and low output impedance. Couples the input to the amplifier circuit without loading the voltage dividers.

Q2, Q3 - Balanced emitter follower-power amplifier. Provides sufficient power gain to operate the 200 μA meter.

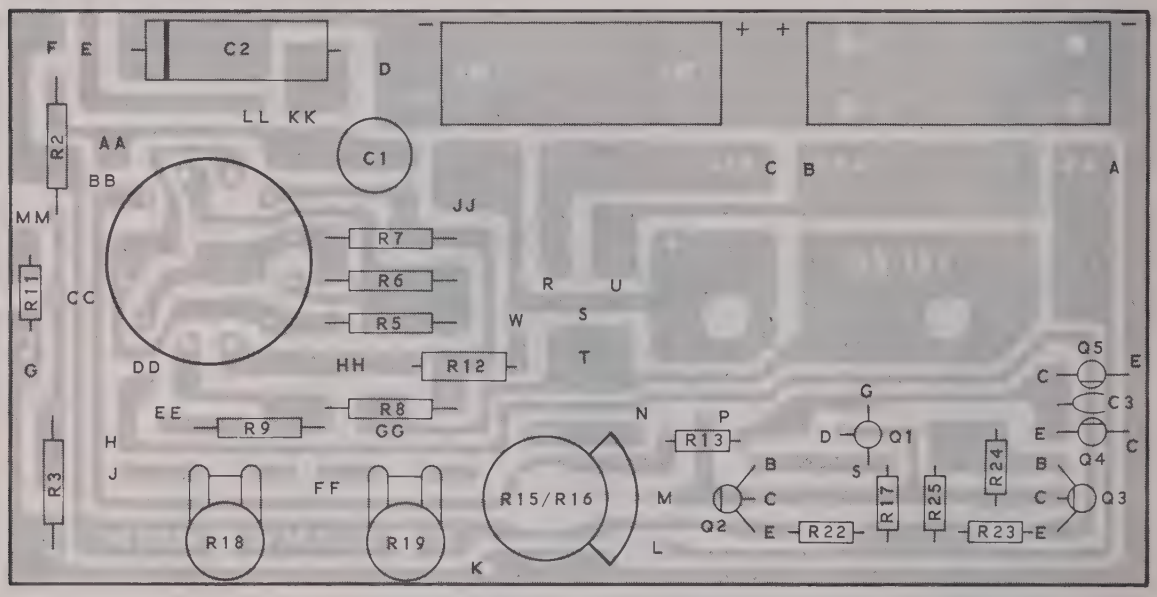
Q4, Q5 - Connected back-to-back as 9 volt zener protection diodes. When the voltage at the gate of Q1 exceeds 9 volts (either polarity) conduction occurs through the appropriate diode, causing a voltage drop across R13. Current limiting action of R13 provides some degree of protection to Q4 and Q5.

PHOTOGRAPH


BATTERY E2
BLUE AND WHITE LABEL
METER
BATTERY E1
R14 ZERO
R21 OHMS
SELECTOR SWITCH
POWER SWITCH
POLARITY SWITCH
PHONE JACK
DC CALIBRATE
AC CALIBRATE
BIAS ADJ

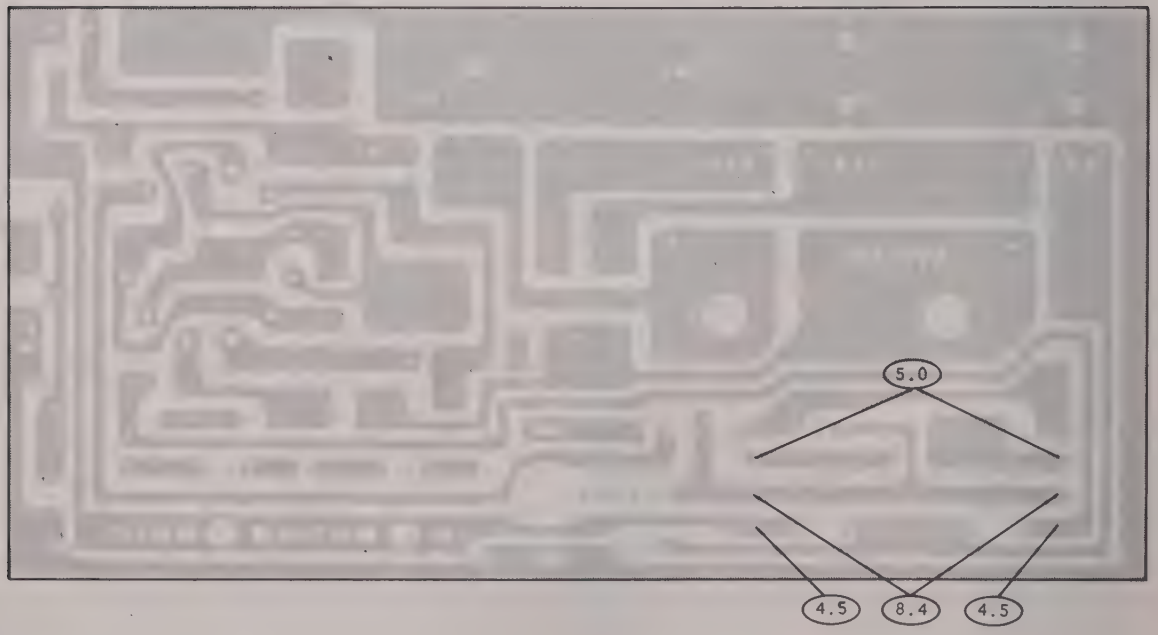
CIRCUIT BOARD X-RAY VIEW

(VIEWED FROM FOIL SIDE)



R1-PROBE
R4-SWITCH
R14-ZERO ADJ.
R21-OHMS ADJ.
D1-ON SWITCH

VOLTAGE CHART

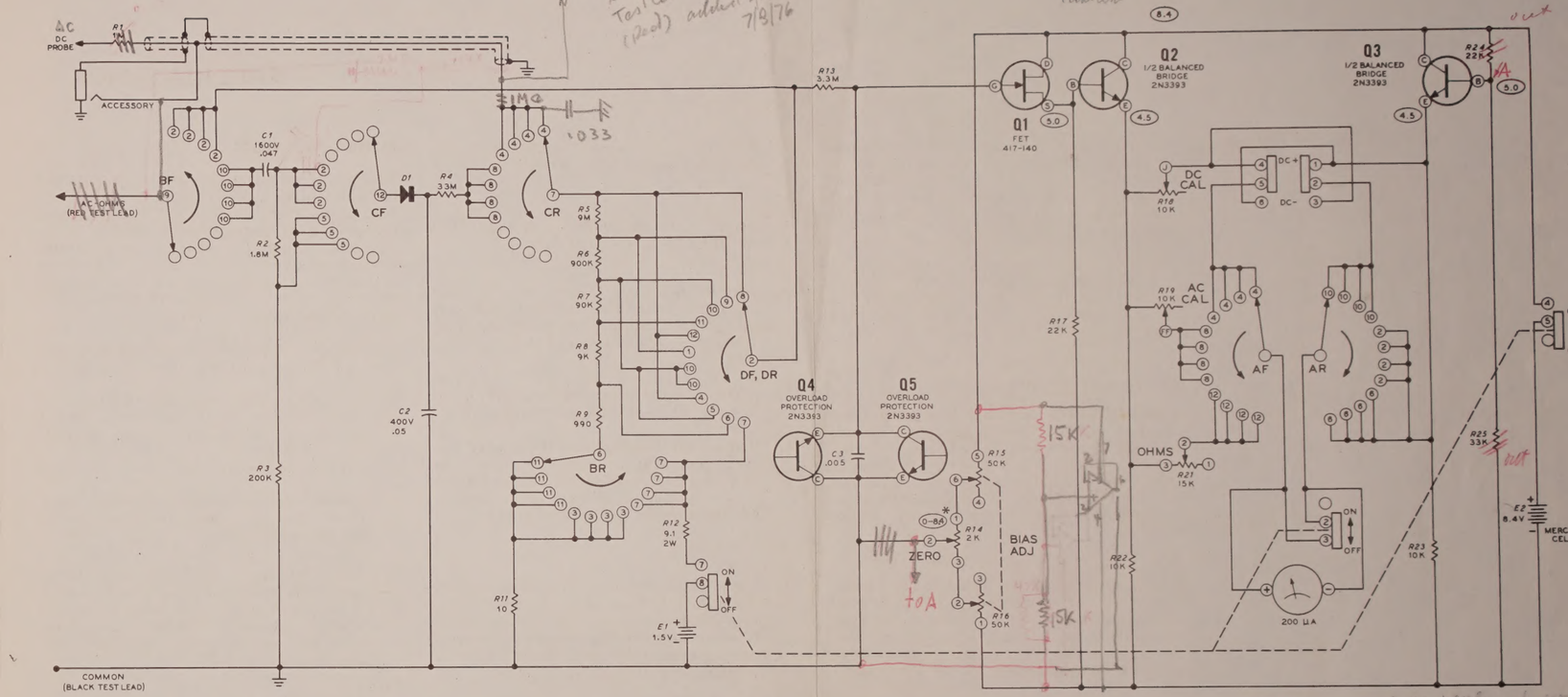


REPLACEMENT PARTS PRICE LIST

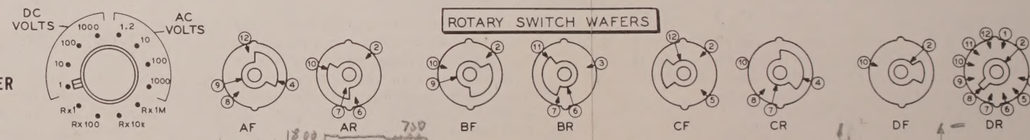
PART No.	PRICE Each	DESCRIPTION
RESISTORS		
1/2 Watt		
1-41	.10	10 Ω
1-20	.10	10 kΩ
1-22	.10	22 kΩ
1-24	.10	33 kΩ
1-35	.10	1 megohm
1-38	.10	3.3 megohm
2 Watt		
3-4-2	.25	9.1 Ω 5%
Precision		
2-236	.20	990 Ω
2-35	.20	9000 Ω (9 kΩ)
2-41	.20	90 kΩ
2-54	.20	200 kΩ
2-51	.20	900 kΩ
2-237	.20	1.8 megohm
2-52	.35	9 megohm
CAPACITORS		
Disc		
21-27	.10	.005 μF
Tubular		
23-91	.50	.047 μF (1.6 kV)
23-61	.15	.05 μF
CONTROLS-SWITCHES		
10-201	.35	10 kΩ control
10-229	.45	2000 Ω control (2 kΩ)
10-78	.45	15 kΩ control
12-80	1.65	50 kΩ dual tandem control
60-2	.25	6-lug slide switch
60-20	.55	9-lug slide switch
63-473	4.00	12-position rotary switch
TRANSISTORS-DIODES		
417-118	.55	2N3393 transistor (or equivalent)
417-140	1.50	FET (field effect transistor)
57-27	.60	Silicon diode

PART No.	PRICE Each	DESCRIPTION
SHIELDED CABLE-WIRE		
343-6	.05/ft	Shielded cable
341-1	.05/ft	Black test lead
341-2	.05/ft	Red test lead
344-50	.05/ft	Black hookup wire
344-52	.05/ft	Red hookup wire
344-59	.05/ft	White hookup wire
HARDWARE		
250-52	.05	4-40 x 1/4" screw
254-9	.05	#4 lockwasher
252-2	.05	4-40 nut
250-229	.05	6-32 x 1/4" phillips head screw
253-10	.05	Control flat washer
254-4	.05	Control lockwasher
252-7	.05	Control nut
MISCELLANEOUS		
73-46	.10	Plastic grommet
214-66	1.00	1.5 V battery holder
214-67	.75	8.4 V battery holder
260-1	.15	Alligator clip
436-20	.45	Phone jack
439-1	.45	Red test probe
439-2	.45	Black test probe
455-50	.10	Knob bushing
462-252	.30	Pointer knob
407-129	9.00	Meter
85-197	1.50	Circuit board
203-507	.85	Panel
95-29	1.60	Plastic case
331-6	.10	Solder
490-5	.10	Nut starter
595-921	2.00	Manual

The above prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Selling prices elsewhere in U.S.A. may be slightly higher to offset transportation and local taxes. Outside the U.S.A. parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties and rates of exchange.



SCHEMATIC OF THE HEATHKIT® UTILITY SOLID-STATE VOLTMETER MODEL IM-17



NOTES

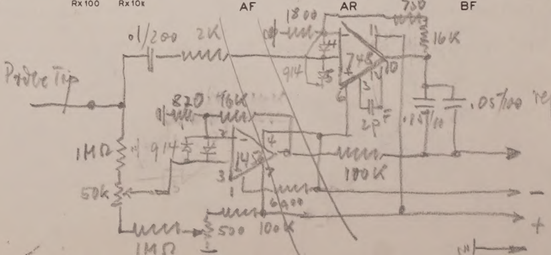
F = FRONT, R = REAR
ROTARY SWITCH IS SHOWN IN 1 VOLT DC POSITION
ARROWS INDICATE CW ROTATION

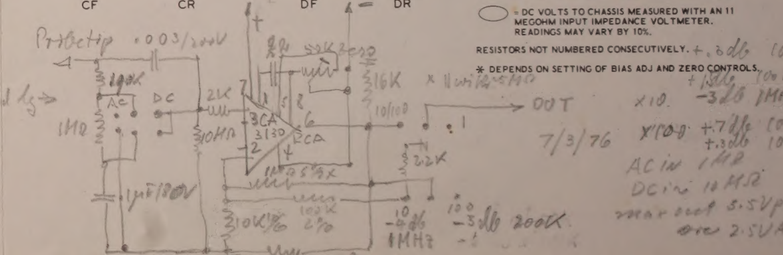
DC SWITCH SHOWN IN "DC+" POSITION
ON-OFF SWITCH SHOWN IN "OFF" POSITION
ALL CAPACITOR VALUES IN μF
ALL RESISTORS ARE 1/2 WATT UNLESS MARKED OTHERWISE
RESISTOR VALUES ARE IN OHMS/K = 1000, M = 1,000,000

= DC VOLTS TO CHASSIS MEASURED WITH AN 11 MEGOHM INPUT IMPEDANCE VOLTMETER. READINGS MAY VARY BY 10%.

RESISTORS NOT NUMBERED CONSECUTIVELY.

* DEPENDS ON SETTING OF BIAS ADJ AND ZERO CONTROLS.





APPLICATIONS

The purpose of this section is to provide those who do not have an electronic background with a few basic applications. These applications will include examples of how this Voltmeter could be used to troubleshoot some items commonly found around your home.

Two types of testing will be discussed: continuity testing, which is performed with the power turned off in the unit being tested; and voltage testing, which is performed with the power turned on.

CONTINUITY TESTING

Continuity testing is a type of circuit checking that uses the resistance ranges of your Voltmeter to tell you whether there is a complete path in a circuit through which an electric current can flow. If there is not a complete path, these tests will help you find the place where the path is broken (usually a faulty part or broken connection).

Continuity tests may be applied to many household electrical devices such as electric irons, heating pads, waffle irons, lamps, extension cords, etc. The following steps use a toaster as an example, but the same principles, and most of the same steps, would also apply to other devices.

CAUTION: Never use the resistance ranges of your voltmeter to test any device while it has power applied to it; this would seriously damage the Voltmeter.

1. CAUTION: Unplug the toaster from the 120 VAC outlet.
2. Turn the toaster's power switch on. This is done by pressing down on the lever until it latches.
3. Set the Voltmeter POWER switch at ON and the SELECTOR switch at Rx1.
4. Clip the black lead to one prong of the line cord plug (make sure the clip touches only one prong), and touch the red probe to the other prong of the line cord plug.
5. If the meter needle remains at INF, there is an open circuit somewhere in the toaster.
6. Remove the housing from the toaster and check the continuity of each line cord wire from the plug to where the wire connects inside the toaster. If there are no breaks, the meter needle will move to zero.
7. Check the continuity of the heating element by touching the black lead to one of its terminals and the red probe to the other terminal. If the element is good, you will get a meter reading between 10 and 20 which indicates a resistance between 10 and 20 ohms.
8. If the heating element checks good, the toaster's power switch is probably faulty. Connect the Voltmeter leads across the switch and turn the toaster on and off several times by pressing and releasing the switch several times. If the meter needle stays at INF, the switch is faulty.
9. Repair or replace the faulty part.

AUTOMOBILE TESTS

Automobile electrical circuits may be checked for both voltage and circuit continuity. Usually most of the metal parts of the automobile are connected together and serve as one side of the circuit for both the DC and the resistance tests. Because many automobile wires run in wiring harnesses and the wire ends may be a long distance apart, it is usually more convenient to make voltage tests than continuity tests.

For example, if the replacement of a lamp bulb does not restore a lighting circuit to operation:

( ) Set the Voltmeter Power switch ON, and the Selector switch to DC 100 (for a 12 volt system) or DC 10 (for a 6 volt system).

( ) Turn the automobile light switch on.

( ) Connect the alligator clip on the black meter lead to a convenient metal part of the automobile body.

( ) Touch the tip of the black probe to the insulated center terminal of the lamp socket. If the meter does not indicate the proper voltage, additional voltage or continuity tests will indicate whether the socket, wiring, or switch is faulty.

VOLTAGE TESTING

CAUTION: Always be very careful when checking electrical circuits with power applied to them. Severe electrical shock or damage to the Voltmeter can easily result from a moments carelessness. When you have a test probe in one hand, keep the other hand in your pocket.

Voltage tests tell you whether the proper amount of voltage is reaching the circuit or device being tested. If the proper voltage is not present, most electrical devices will not operate properly.

Voltage tests can be used, for example, to check the batteries of a portable radio or other battery operated device. Note though, that the device must be turned on and drawing current from the batteries to make this test valid.

To test the voltage of a battery, turn the device on, turn on the POWER switch of the Voltmeter, and set the SELECTOR switch to an appropriate DC range. Connect the black test lead to the negative battery terminal and the DC test lead to the positive terminal. If the voltage measures 20% or more less than the nominal voltage printed on the battery, the battery should be replaced.

For another example, voltage tests could be used to find the trouble with a faulty doorbell in the following manner:

1. Turn the Voltmeter on and set the SELECTOR switch to the 100 volt AC range.
2. Touch the black test lead to one terminal and the red test probe to the other terminal of the doorbell buzzer or chimes unit. When the doorbell is pressed a voltage between 6 and 24 volts should appear at these terminals. If this voltage does appear and the doorbell does not work, this mechanism is faulty and must be replaced.
3. If no voltage was present in the previous test, locate the bell transformer. This transformer, which can usually be found mounted to a ceiling rafter in the basement, steps the 120 volt AC line voltage down to the lower voltage that operates the bell.
4. Study the wires that connect to this transformer. One set of wires will lead to the doorbell and buzzer or chimes unit; the other set will lead to a source of 120 volts AC at the fuse box.
5. Check the AC voltage at the output terminals (where the wires leading to the doorbell are connected) of this transformer just as you did in step two above. If you have the proper voltage at this point, the push button, wiring, or bell is faulty.
6. If no voltage is found in the preceding step, check for line voltage (turn the SELECTOR switch to AC/1000 volts) at the two wires going to the fuse box. If proper line voltage is found, the connections are poor or the transformer should be replaced.
7. If no voltage is found in the preceding step, the fuse is blown or there is a fault in the circuit wiring.

TESTING NOTES

1. Before you test a household appliance or other AC-operated device, be sure the AC outlet that it is plugged into is operating. The quickest way to do this is to plug into the outlet a lamp that you know has a good bulb in it. If the lamp lights, the outlet is O.K.
2. By removing the fuse for the circuit from the house fuse box, you can completely turn off a house circuit. This would enable you to make continuity tests on devices that are directly wired to the fuse box, such as electric motors, bell transformers, etc. Keep the removed fuse in your pocket so no one can replace it while you are working on the circuit.

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